

The AMSAT[®] Journal

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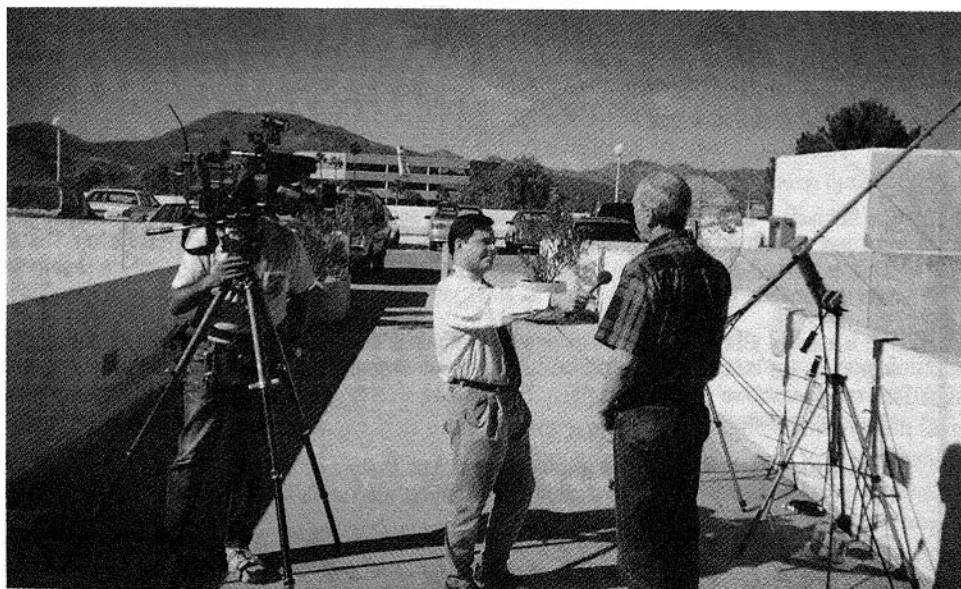
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Local news media were very interested in learning of AMSAT accomplishments. At the symposium's satellite antenna site, Chuck Green, N0ADI briefed a local Tucson television station on Phase 3D efforts. The segment aired on the local evening news. (KC5JVB photo)

AMSAT Comes to Tucson!

14th Space Symposium and Annual Meeting a Success!

A large number of AMSAT members converged on the Holiday Inn City Center in Tucson, Arizona the weekend of November 8-10, 1996 for the AMSAT-NA's 14th Annual Space Symposium and Annual Meeting. Over 300 participants from 14 countries attended the three day conference to hear 30 presentations.

From Friday morning to Saturday afternoon, a host of presentations on amateur satellite topics were given that included:

- ASUSAT: A Low Cost AMSAT Nanosatellite, Dr. Helen Reed, Arizona State University Satellite Laboratory Director
- SEDSAT Project Update, Dennis Wingo, KD4ETA

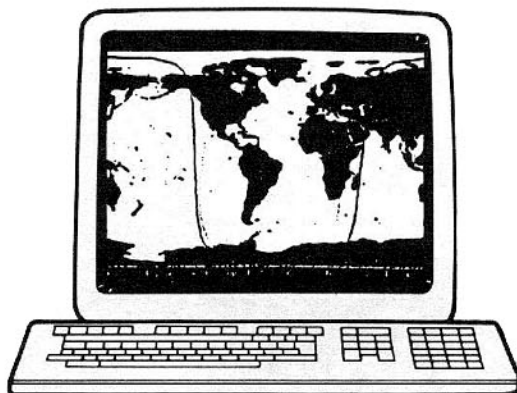
[continued on page 5]

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Silver Spring, MD 20910

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Satellite Tracking

with your PC and the Kansas City Tracker & Tuner



The **Kansas City Tracker** is a hardware and software package that connects between your rotor controller and an IBM XT, AT, or clone. It controls your antenna array, letting your PC track any satellite or orbital body. The **Kansas City Tracker** hardware consists of a half-size interface card that plugs into your PC. It can be connected directly to Kenpro 5400A/5600A or Yaesu G5400B/G5600B rotor controllers. It can be connected to other rotor assemblies using our Rotor Interface Option.

The **Kansas City Tuner** Option provides automatic doppler-shift compensation for digital satellite work. The **Tuner** is compatible with most rigs including Yaesu, Kenwood, and ICOM. It controls your radio thru the radio's serial computer port (if present) or through the radio's up/down mic-click interface. The **Kansas City Tuner** Option is perfect for low-orbit digital satellites like the NOAA and Microstat satellites.

The **Kansas City Tracker** and **Tuner** include custom serial interfaces and do not use your computer's valuable COMM ports. The software runs in your PC's "spare time," letting you run other programs at the same time.

The **Kansas City Tracker** and **Tuner** programs are "Terminate-and-Stay-Resident" programs that attach themselves to DOS and disappear. You can run other DOS programs while your antenna tracks its target and your radios are tuned under computer control. This unique feature is especially useful for digital satellite work; a communications program like PROCOMM can be run while the PC aims your antennas and tunes your radios in its spare time. Status pop-up windows allow the user to review and change current and upcoming radio and antenna parameters. The KC Tracker is compatible with DOS 2.00 or higher.

Satellite and EME Work

The **Kansas City Tracker** and **Kansas City Tuner** are fully compatible with N4HY's QUIKTRAK and with Silicon Solution's GRAFTRAK. These programs can be used to load the **Kansas City Tracker's** tables with more than 50 satellite passes.

DX, Contests, and Nets

Working DX or contests and need three hands? Use the **Kansas City Tracker** pop-up to work your antenna rotor for you. The **Kansas City Tracker** is compatible with all DX logging programs. A special callsign aiming program is included for working nets.

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The **Kansas City Tracker** comes complete with special control programs that allow the packet BBS user or control-op to perform automated antenna aiming over an hour, a day, or a week. Your BBS or packet station can be programmed to automatically solicit mail from remote packet sites.

Vision-Impaired Hams

The **Kansas City Tracker** has a special morse-code sender section that will announce the rotor position and status automatically or on request. The speed and spacing of the code are adjustable.

The **Kansas City Tracker** and **Tuner** packages include the PC interface card, interface connector, software diskette, and instructions. Each Kansas City unit carries a one year warranty. The KC Tuner is not available as an after market upgrade.

- KC Tracker package includes cable for Yaesu/Kenpro 5400/5600 and rotor interface option (to connect any rotors) \$229
- KC Tracker package plus KC Tuner \$319

Visa and MasterCard accepted.
Shipping and handling: \$5, (\$20 for international shipments).
Prices subject to change without notice.

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For more info: Telephone 609-751-1018
FAX 609-751-9705

AMSAT-NA can take your order for a Kansas City Tracker/Tuner or one of many Satellite Tracking software packages that support the KCT, such as Quiktrak, Graftrak, and WiSP for Windows. When you order thru them, they receive a Donation in your name towards the Phase 3D Project. Their telephone number is 301-589-6062.



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The AMSAT Journal staff is always interested in article submissions. Whenever possible, text should be on IBM compatible diskette (3 1/2 inch preferable) with hard copy and original photographs and figures. AMSAT-NA reserves the right to select material for *The AMSAT Journal* based on suitability of content and space considerations. The editors of this publication are volunteers giving freely of their talents, time, and efforts to produce *The AMSAT Journal*.

Apogee View

We Must All Help! by Bill Tynan W3XO

What is the most important and irreplaceable resource we amateurs possess? No, it isn't that fancy new \$4,000 transceiver and \$3,000 linear we just bought in order to stay on top of the Honor Roll. For us amateur satellite enthusiasts, it isn't even the spacecraft that have been put up there for us at considerable expense and untold hours of volunteer labor. For example, by the time Phase 3D is launched, it will have consumed a monetary outlay of some \$4,000,000 and many thousands of manhours of time. As valuable to us as our radios and our satellites are, they are not our most important resource. No, our most important resource is that for which we have not had to pay a dime, at least until now. It is those portions of the radio frequency spectrum that have been allocated to us.

If we are to continue to enjoy the many facets of our hobby, it is vital that we retain sufficient spectrum to pursue the various modes of operation and activities that have made Amateur Radio what it is today.

Not since 1919 has Amateur Radio been faced with a more serious situation when it comes to retaining our frequencies. This is particularly true in the case of the UHF and microwave bands but is applicable to all of our allocations. Just after World War I, it was seriously proposed by many high in government, that Amateur Radio should be not be reestablished after having been suspended during the war. Prior to World War I, amateur operation was largely an unlicensed activity engaged in by a small group of young experimenters who taught themselves the Morse Code and built their own spark transmitters and crystal receivers. There were no band assignments and, indeed, very little selectivity existed in receivers or transmitters of the day - amateur or otherwise. So, getting on the air was sort of a free-for-all proposition, even for government and commercial stations.

But following the Armistice in November 1918, the American Radio Relay League, under its President and founder,

Hiram Percy Maxim W1AW, stepped in and saved the day for the hams who had been chafing at the bit to get back on the air. More important, the young League was able to establish Amateur Radio as a recognized radio service. Ever since that time, the ARRL has been our most effective spokesman in the halls of our Government; and, through the International Amateur Radio Union (IARU), an organization made up of national amateur radio societies throughout the world, overseas governments have also been convinced that preserving small slices of radio spectrum for use by licensed amateur radio operators is in the public interest.

But many factors have presented the Amateur Radio Service and the Amateur Satellite Service with a new challenge, every bit as formidable as that which faced the fledgling ARRL back in 1919. Among these factors are some which we, ourselves as amateurs, have brought about. Since the early days of radio, hams have been active in identifying new technologies and demonstrating their effectiveness. We were among the first to show that the shorter wavelengths were useful - in fact more useful for some types of communication than the longer waves. We led the way in very selective receivers and later demonstrated the utility of single sideband for small stations. SSB had been used since the 1920s by large overseas telephone installations, but not for the kinds of stations typical of home-based amateur rigs, much less mobiles and portables. We showed the usefulness of the VHF bands for something other than line-of-sight communication. In recent years, we demonstrated the utility of low earth orbit satellites for store-and-forward communication. This has been one of the contributions which threatens to bite us by forcing us to relinquish, or share, part or all of one of our most used VHF bands.

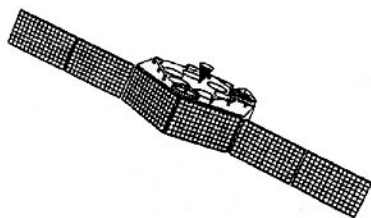
The development of satellites in general has completely changed the picture of what is considered usable spectrum. Whereas they were previously perceived as useful only for local line-of-sight work, now, the microwave bands are known to be readily usable for worldwide communication. While this has taken some of the pressure

off of our HF bands, it has put it squarely on the part of the spectrum we amateur satellite enthusiasts value most.

The other major threat comes from the fact that governments have learned that they can derive significant revenue by *selling* spectrum. This has put a Billion Dollar pricetag on each MHz of spectrum now assigned to us amateurs. We cannot possibly match the prices being paid by commercial interests, so we must survive by convincing government officials of all countries that Amateur Radio is worth preserving, and that it must have sufficient spectrum in which to carry on the many kinds of operation and experimentation which has typified it over the years. Yes, it is 1919 all over again - maybe even worse.

As in 1919 and the intervening years, the ARRL and the IARU member societies are our best chance of preserving the spectrum so vital to our continued existence. In September, League members received a letter signed by ARRL Executive Vice President Dave Sumner K1ZZ. The letter made a good case for the need to continue the fight to preserve amateur spectrum and the fact that doing so requires the expenditure of a significant amount of money.

I want to go on record as supporting the League in this effort. It is the organization that can have the most impact. That does not mean that AMSAT will not be involved as well. We will continue to support the League in its spectrum preservation efforts in every way we can - offering technical advice and commenting directly when appropriate. But we are not equipped to support the attendance at meeting after meeting and make innumerable visits to FCC and Capitol Hill that ARRL is able to do. Therefore, I urge all AMSAT members to respond to Dave Sumner's plea for financial contributions in support of the one thing Amateur Radio cannot exist without - our vital and valuable spectrum. I plan to contribute and ask that you do likewise. ■



1996 AMSAT Awards

Amateur Satellite Construction

- David Liberman, XE1TU & the UNAMSAT Team for the construction of Mexico-OSCAR-30
- JARL for Fuji-OSCAR-29

General Services to AMSAT

- Jim O'Neill AMSAT Travel Agent
- Ron Broadbent MBE, G3AAJ Raising Significant funds
- Ray Soifer, W2RS Drafting FASC Recommendations
- Ed Krome, KA9LNV AMSAT books and lectures
- B. J. Arts, WT0N AMSAT News Service
- Pat Kilroy, WD8LAQ Washington, DC Area AMSAT Organization
- Dan Schultz, N8FGV

Command Station Operation

- Ian Ashley, ZL1AOX
- Stacey Mills, WB4QKT
- Robert Diersing, N5AHD
- Jim White, WD0E

Software

- Michael Owen, W9IP

AMSAT Net

- Cliff Buttschardt, K7RR Pacific Coast 75 Meter Net
- Marty Smith, WD5DZC Houston Net
- Michael Reynolds, W0KIE and The Oklahoma Network Relaying Houston Net

The AMSAT Journal

- Russ Tillman, KC5JVB
- Ron Long, W8GUS

Phase 3D

- Bdale Garbee, N3EUA
- Bill Hickey, WA5FXE
- Frank Bauer, KA3HDO
- Phil Chien, KC4YER
- Hank Sill AC4ZI
- Chuck Hennessey, W4AT
- Fred Kennedy, ZL1BYP
- John Darbyson, WB4MOX
- Bernard Pidoux, F6BVP
- Christophe Carlier, F4AAT
- John Conner, WD0FHG
- Ron Luse, KD9KX

Field Operations

- Howard Ziserman, WA3GOV
- Gary Rogers, WA4YMZ,
- Kermit Carlson, W9XA
- Jim Weisenberger, AA7KC

Dayton Hamfest Help

- Barry Baines, WD4ASW
- Terry Douds, WB8CKI
- James Kelly, KK3K
- John Boudreau, VE8EV

SAREX

- Tim Bosma, AB6FL Telebridge Station
- Rich Weigand, AH6MC Telebridge Station
- Gerald Klatzko, ZS6BTD Telebridge Station
- Santa Rosa Junior College Telebridge Station
- Edison Radio Amateur Association STS-67 QSLs
- Sacred Hearts Academy Radio Club STS-71 QSLs
- Sterling Park Amateur Radio Club STS-70 QSLs
- Greater Norwalk Amateur Radio Club STS-74 QSLs
- Nashoba Valley Amateur Radio Club STS-76 QSLs

AMSAT Annual Meeting and Space Symposium Organizers

- Heather Johnson, N7DZU Co-Chairman
- Larry Brown, NW7N Co-Chairman
- Dave Burnett, WD8KRV Program Chairman
- Dave Medley, KI6QE Prize Chairman
- Sue Burnett, Family Activities
- Darrel Emerson, AA7FV Banquet Speaker
- Scott Bulau, KA7CUZ Organizer of the Kitt Peak Optical Telescope tour.
- Greg Michels, KB7WFO Satellite Station

AMSAT Field Day Competition

- The North Shores Amateur Radio Club and Dave Guimont, WB6LLO
- The Hack Shack (KA1VEC, KA1VED & NM1K), 1995 AMSAT Field Day Competition Winner ■

Continued from page 1

- A Time Code Reader/Display for Russian Tsikada Satellites, John Franke, WA4WDL
- Picosat System, Peter Vekinis, KC1QF
- Amateur Radio on the International Space Station, Frank Bauer, KA3HDO
- AMSAT Satellites and ESA Launches, Gould Smith, WA4SXM
- Spread Spectrum Tutorial, Phil Karn, KA9Q
- TECHSAT Project Update, Assi Friedman, 4Z7ABA
- SETI Sensitivity: Calibrating on a Wow! Signal, Dr. Paul Shuch, N6TX
- Computer Interfacing the Hamshack, Tom Boza, WB7ASR
- AMSAT: A Tutorial for Beginners, Barry Baines, WD4ASW
- Keplerian Element Fundamentals, Ken Ernanandes, N2WWD
- (My) Hamshack of the Future, Andrew Skattebo, KA0SNL
- Quick, Inexpensive, and Effective: A Simple Satellite Mobile QRP Station for the Beginner, Doug Quagliana, KA2UPW
- RS-10 Landfill Station, Bill Rausch, AA6PA
- A High Performance Satellite Modem, Phil Karn, WA9Q
- Amateur Satellites - Is There a Future, Richard Limebear, G3RWL
- Amateur Satellite Service in 1996, Ray Soifer, W2RS
- FO-29 Project Update, Harry Yoneda, JA1ANG
- Highly Accurate Time/Frequency Application for Amateur Applications, Tom Clark, W3IWI
- A Possible Phase 3D Follow-on Project, Bill Tynan, W3XO
- The View from Below: Thoughts on Phase 3D Ground Station Requirements, Ed Krome, KA9LNV
- Mir SAFEX-II Update, Thomas Kieselbach, DL2ME
- Dove and Webersat Recovery Status, Jim White, WD0E

In addition, the following presentations were devoted to Phase 3D:

- Phase 3D Update, Dick Daniels, W4PUJ
- Phase 3D GPS Receiver Progress Report, Bdale Garbee, N3EUA
- RUDAK Update, Chuck Green, N0ADI

The Saturday evening banquet was a notable success with Darrel Emerson, AA7FV giving an enjoyable talk on amateur radio's contributions to radio astronomy. Afterwards, AMSAT President Bill Tynan, W3XO presented ARRL Vice President Joel Harrison, WB5IGF with a

plaque that dedicated Phase 3D's spaceframe in recognition of ARRL support of the project. In addition, various awards were given to numerous members for the service to AMSAT in 1996 (see page 4). The evening banquet concluded with a multi-prize drawing. Grand Prizes were won by John Brand, K6WC (IC-820H donated by ICOM America) and Ib Christoffersen, OZ1MY (Kenwood TM251-A donated by Loren Pleet, AE6P of Kenwood Communications). Also, Leanore Guimont, KA6UCD presented Ed Krome, KA9LNV with a brooch from the 4th Annual Electronic Jewelry Contest.

Ed correctly identified the brooch that was constructed from field coils from the pancake bar of a 3½ drive by David Guimont, WB6LLO.

The 1996 *Proceedings of the AMSAT-NA 14th Space Symposium* are now available from AMSAT-NA Headquarters (see page 29).

Now's the time to make plans for AMSAT-NA's 15th Annual Space Symposium and Annual Meeting which is scheduled to be held 17-19 October 1997 in Toronto, Ontario, Canada. ■

Many thanks to the following individuals and corporations for donating prizes:

- IC-820H 2M/70cm Multi-mode Transceiver, ICOM America
- TM-215A Two-meter FM Transceiver, Kenwood Communications
- Kansas City Tracker, L. L. Grace
- M2 432CP1 Circular Polarized Antenna, The Ham Shop
- Two-meter Eggbeater Antenna, M2 Antennas
- Mobile Antenna Gift Certificate, Larsen Antennas
- Propman Prediction Software (2), Rockwell International Corporation
- MFJ-107B Digital Clock (8), Fox Hunt Adventure Book (3), Packet Radio Beginner's Guide Book (10), MFJ Enterprises
- P3D 400 bps Data Demodulator PCB, James Miller, G3RUH
- Hamcall CD ROM, Buckmaster
- The World of Ham Radio CD ROM (4), AMSOFT
- The Rhythm of the Code Tapes (5), KAWA Records
- CQ VHF Ham Radio, Communications Quarterly, CQ Amateur Radio subscriptions, CQ Communications, Inc.
- Solder Kit, Silver Solder and Grabscrews Kits (12), Solder-it Company
- ARRL Satellite Experimenters Handbook, Pace Engineering
- CoAxial Relay, Ham Radio Outlet
- The 1997 ARRL Handbook, The ARRL Antenna Book, The Satellite Experimenter's Handbook, Cliff Hauser
- The Satellite Experimenter's Handbook, The 1997 ARRL Handbook (3), ARRL CD ROM, ARRL Satellite Anthology (4), The ARRL Antenna Book, Radio Design Package, American Radio Relay League
- SP144vdc GASFET Preamp, Advanced Receiver Research
- Windows NT Package Workstation (4) and Server (2), Joe Holman, KA7DLN
- Toshu Antenna Relay, Henry Radio
- AMSAT Membership, OSCAR Satellite Report subscription (2), Craig Mellinger, N2MNA
- TAPR Coffee Cups (4), Tucson Amateur Packet Radio
- TNC-DSP93, PacComm
- JAMSAT T-Shirts (5), JAMSAT
- 25 M Aircom w/connectors, SSB Electronics
- Mode J Desense Filter, PAR Electronics
- SETI Pocket Protector, The SETI League
- Basic Guide to Digital Satellites, Highspeed Packet Radio Connections, New Guide to Amateur Radio Satellite Operations, Introduction to Simple Orbital Deractions, AMSAT-UK
- Astronomy Poster, National Optical Astronomy Association

Mir/SAFEX II Operation

Mike Seguin, N1JEZ and Tom Lubbers, K8TL

We have had a good time lately operating the new Mir/SAFEX II 70cm repeater. We hear quite a few people trying to use it. They may key it up briefly, but they do not hold it. There seems to be some confusion about its operation. Here are a couple of ways that we use to operate RR0DL successfully.

The two biggest problems are CTCSS tone and doppler shift. First you need to use a 141.3 CTCSS tone to be able to bring up the repeater. Second, you must compensate for Doppler shift on both the downlink and well as the uplink (unlike AO-27). This confuses some people.

The 70cm Doppler can be as much as +/- 10 kHz. Standard downlink Doppler for a pass starts high in frequency and ends low. On your radio, you simply tune high at the start and move down in frequency during the pass. Now, here is the catch! On the uplink, Mir hears your signal the same way. i.e. high at the start and ending low. Since you cannot tell Mir to adjust its receive frequency, you must compensate by adjusting your transmit frequency. You need to start the pass on the low side and increase the frequency as the pass progresses. It's the opposite of the receive Doppler.

This is where we think people are getting confused.

Here are a couple of ways to operate the Mir repeater with a Yaesu FT-736R:

1. Program a series of memory channels for +/- 8KHz Doppler correction. This method should be applicable to other radios as well. Use a sequence of standard memory channels (not Sat channels) set up as minus offset with tone encoding. First, program the downlink frequency, then enter the offset. Make sure you are set for negative offset and tone encoding of 141.3 Hz,

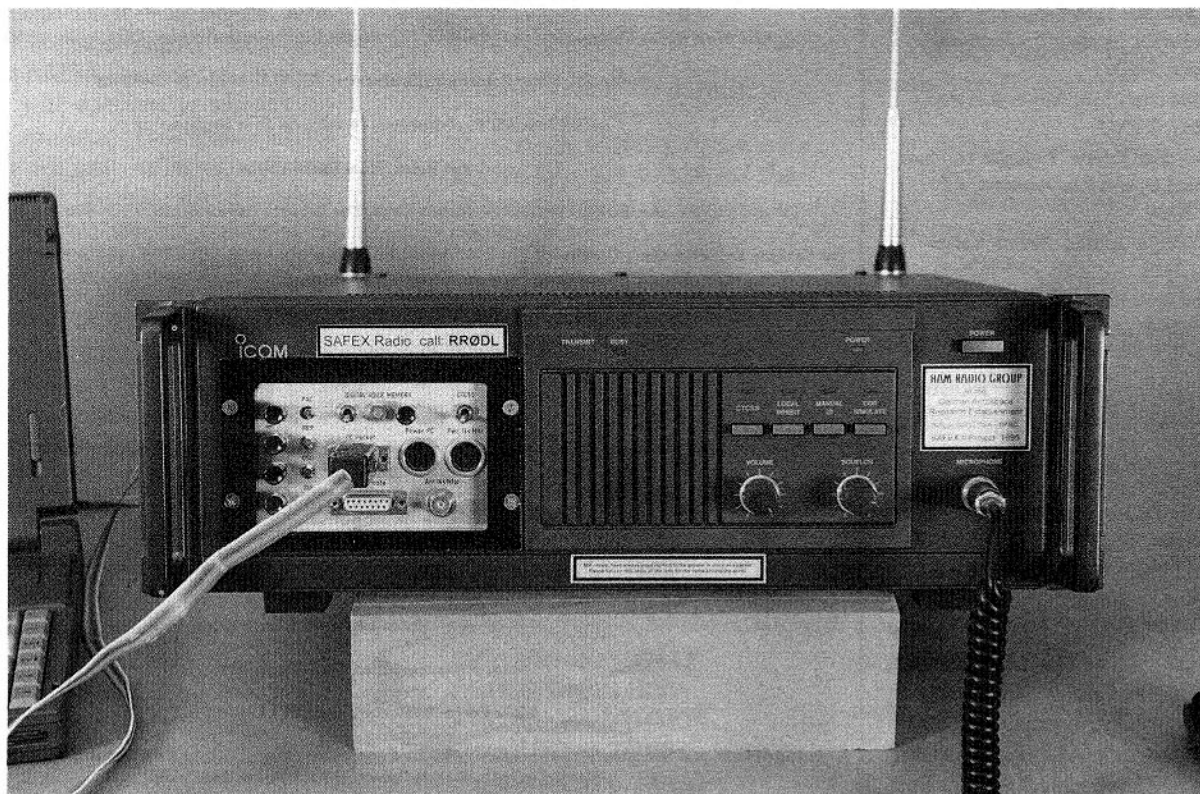
(you do have the FTS-8 tone board installed, don't you? It's an option!), then save to a memory channel. The frequencies are set for each channel according to the list below.

Mir/SAFEX 70cm Doppler Correction

Downlink (MHz)	Uplink (MHz)	Offset (MHz)
437.958	435.742	2.216
437.956	435.744	2.212
437.954	435.746	2.208
437.952	435.748	2.204
437.950	435.750	2.200
437.948	435.752	2.196
437.946	435.754	2.192
437.944	435.756	2.188
437.942	435.758	2.184

During a pass, start with the first channel, and tune up channel by channel as the pass progresses. Set your meter to DISC/ALC and keep the meter centered as well as possible on receive. If you don't have enough memory channels, make larger steps near the center of the passband. Mir spends more time near the ends of the Doppler shift than it does in the middle.

2. Use full time automatic Doppler correction via CAT utilizing NOVA 1.1 for DOS. Mike posted how to use this method to the NOVA reflector a while back. There is a minor problem with the way NOVA works with CTCSS while doing automatic tuning, but there is a simple *work around*. If you are interested, drop Mike a note and he'll send you a copy. The address: n1jez@amsat.org. ■



SAFEX-II Project Leader Thomas Kieselbach, DL2MDE recently provided a photograph of the 440 MHz repeater that is presently aboard Mir.

AMSAT-CE Project CESAR-1

Eduardo A. Diaz, CE3GA
edodiaz@tamarugo.cec.uchile.cl

The Chilean Federation of Amateur Radio Clubs, considering the needs of the local community of amateur radio operators for learning, experimenting and practicing the technological developments that have enabled colleagues in other countries to design construct and operate experimental small telecommunications satellites, in April 1992 established The Foundation for the Development of Amateur Radio Satellites, AMSAT-CE, as a non-profit organization responsible for conducting similar activities in Chile.

AMSAT-CE intends to unite the efforts of amateur radio operators, university professors, private sector entities, and other interested parties to accomplish its objectives, which are initially expressed in a first satellite project. The microsat being developed has been designated as **CESAR-1** (**CE** (Chilean amateur radio call sign prefix) **S**atellite for **A**mateur **R**adio) an acronym that also works in Spanish (Satélite para Aficionados a las Radiocomunicaciones). Even though AMSAT-CE has already discussed launch possibilities with a well known US launcher, the launch date has not been defined and will not be defined until at least a finished engineering version of CESAR-1 has been produced.

The theoretical cost of this first project, estimated as US \$1,000,000, in actual cash money terms is only around US \$400,000; professional man-hours, installations and other contributions make up the difference. The cash-money amount is expected to be financed with contributions made by local industry, local businesses, and member donations. Our main sponsor up to now has been ENTEL-CHILE, the older and now private satellite telecommunications company in Chile.

Benefits and Projections

We expect to derive various positive consequences from this satellite project. The most important perhaps would be to make the Chilean citizens aware of the fact that space is a realm not only reserved for the historically so-called space nations but also accessible to determined and organized people; that we amateur radio operators can continue to develop our hobby also in the environment of outer space, and that it is still possible for amateur radio experimenters to make contributions to science and technology through the implementation of ambitious endeavors such as CESAR-1.

Designing, building, and operating an artificial Earth satellite implies a complex interdisciplinary work employing peak technology. The experience to be gained during these efforts will create a strong group of amateur radio experimenters, university professors, and other kinds of professionals, who will have proved to themselves and the local community that more difficult tasks can be tackled, to accomplish scientific and technical objectives perhaps deserving industrial and governmental support.

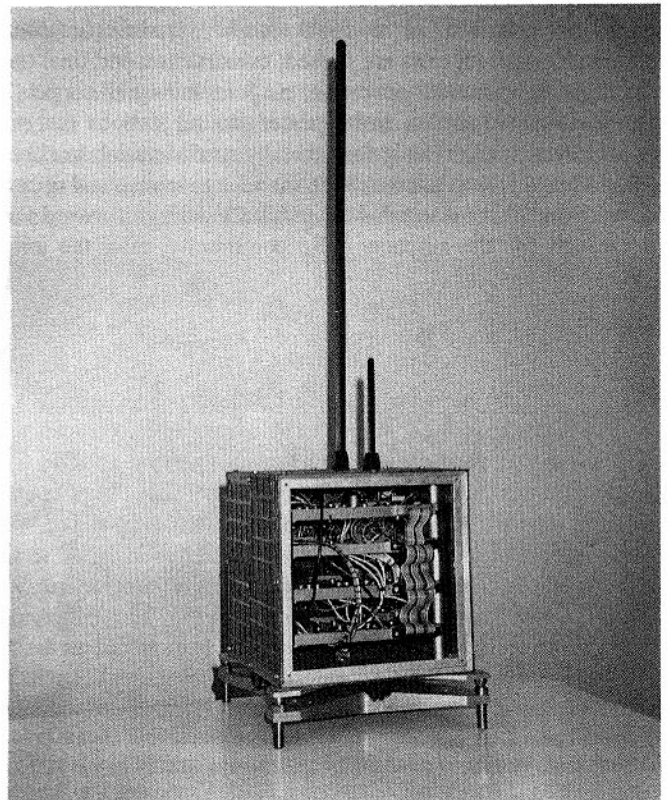
The possibility for AMSAT-CE to have access to this technology, at a nominal cost, through its colleague organization in the U.S., AMSAT-NA, represents a contribution of a magnitude not otherwise reachable by Chilean hams. Suffice it to say that this technology is the result of thirty years of satellite experimentation by the worldwide amateur radio community. We certainly are thankful for the help of many experienced colleagues to get this project off the ground.

Educational Benefits

This project includes a plan to disseminate information among students in basic, high-school, and college education by means of publications and practical demonstrations utilizing satellites presently in orbit, to teach them the basics of celestial mechanics and satellite radio communications, with emphasis on practical applications for the transmission of voice and data.

Scientific and Technological Benefits

Valuable volunteer work is being contributed by amateur radio experimenters, college professors, and college students. The experience they will gain by having access to satellite technology through this project will undoubtedly be beneficial in future satellite or space related projects in which they might participate. This proliferation-effect we are trying to initiate is totally in line with the tradition of amateur radio. In this case it will benefit our hobby and also our nation.



CESAR-1 engineering prototype (AMSAT-CE photo).

Economic Benefits

Even though this first satellite project obviously does not directly imply an impact on the economy of Chile, its participants will realize that the feasibility of opening technological packages, previously considered a privilege of developed nations, is also real for people with a project, a well-defined plan and a strong will to carry it out. This experience could then propagate toward areas of economic importance.

The fact that this is an amateur radio experimental satellite project does not necessarily restrict future projects to the field of amateur telecommunications; this experience will also be valuable for, say, developing a future remote sensing satellite a scientific spacecraft, or a commercial mobile telecommunications system. Future projects may certainly have important positive economic implications, but CESAR-1 is a necessary and required first step.

International Benefits

Since Amateur Radio satellites are used internationally, a Chilean contribution to the present sky network will certainly promote an improved image of our country among our colleagues the world over. Also, since presently there are no more than twenty nations having their own satellites, for Chile to become one of them is definitely relevant for its participation not only in international political forums but in technical discussions and activities related to the peaceful uses of outer space. This relevance will be enhanced by the fact that this satellite is being built in Chile by Chileans.

Projections

Present plans of AMSAT-CE are to learn from all stages of this first project (design of and construction of the engineering model; construction and test of a flight model; modifications and improvement until all tests are passed; construction and final tests of the flight unit; launch, operation, etc.). Including all aspects of the ground control station and repeater ground stations that will have to operate continuously for several years. Materials are being bought to build five microsats, with the idea to launch and operate three of them. This means that AMSAT-CE will go forward with new projects for the amateur radio community, after the initial experience of CESAR-1.

Description of CESAR-1

CESAR-1 will be a microsat in a heliosynchronous orbit at 800km altitude. It will carry five experiments in an enclosure of cubical shape, the cube measuring 23 centimeters on the side. The structure of the cube consists of five modules made out of special aluminum. The external faces of the cube will be covered with Ga-As solar cells to charge the 8 Ni-Cd batteries installed in the center module. Antennas made out of pieces of steel measuring tape are mounted on the -Z face for transmitting the UHF signals of Experiment 1. The VHF receiver antenna is mounted on the +Z face. The S-band transmitting antenna of Experiment 3 will be mounted on the -Z face. The location of the GPS receiver antennas will be on the +Z face.

The following are the experiments to be carried on board CESAR-1:

- **Experiment 1:** A VHF/UHF packet radio transponder, similar to those already aboard active amateur radio satellites, operating with FSK modulation at 9.6kbps. It will operate in real-time mode. The 3 VHF receivers will be installed in the upper or first module. The UHF transmitters will be installed in the lower or fifth module.
- **Experiment 2:** A similar packet radio transponder, but operating in a store-and-forward mode.
- **Experiment 3:** A voice synthesizer. A FM/ VHF broadcast experiment with the idea of allowing even high-school students to receive messages from this LEO amateur satellite. An optional type of message will be the satellite position as derived from the GPS receiver in Experiment 5.
- **Experiment 4:** A digital voice L/S band transponder which will operate with ad-hoc VHF-L/S-VHF ground repeater stations to enable Amateur Radio operators, using even VHF hand-held transceivers, to communicate with colleagues located beyond line-of-sight distances during the period of mutual visibility between the spacecraft and both ground stations. The S-band transmitter will be located in the lower or module 5. The L-band receiver will share module 2 with the VHF receivers.
- **Experiment 5:** A GPS receiver to obtain 3 dimensional position data from the existing constellation of 24 GPS satellites. This effort is based on the initial development of the P3D GPS receiver; this is another valuable collaboration from AMSAT-NA. The GPS receiver will be installed in the second module.

Ground Segment

The Ground Segment of this project will consist of the CESAR-1 Control Station and the VHF/L/S/VHF repeater stations.

CESAR-1 Control Station

The objectives of the Control Station are:

- Make sure that early orbit life of the spacecraft is initiated properly.
- Ensure the safe and long life of the spacecraft.
- Solve as quickly as possible any contingencies affecting the safety or performance of the spacecraft.
- Program the activity of all experiments to satisfy their objectives, commensurate with power availability and battery life (spacecraft power management).

The Control Station equipment will consist of:

- Receivers and antennas compatible with all spacecraft transmissions.
- Transmitters and antennas compatible with all spacecraft receivers.
- One exact replica of the spacecraft to help in the analysis of problems experienced during the active life of the spacecraft.
- Computers, peripherals, ARTIC board, builders, software, used in the spacecraft and during the development of the spacecraft systems and the ground stations.

- All documentation i.e. manuals, drawings, diagrams, part lists, specifications, etc.

Digital Voice Repeater Stations for Experiment 4

These stations will consist of the following components:

- A VHF 2m FM repeater. The audio or voice output of its FM receiver will be digitized and uplinked to the satellite. The audio or voice recovered from the S-band downlink will be broadcast by the repeater.
- An analog-to-digital converter to digitize the voice or audio received from the FM. receiver in the repeater.
- An L-band transmitter, to uplink the digitized audio.
- An S-band receiver tuned to the satellite S-band downlink.
- A digital-to-analog converter to recover the analog version of the audio coming from the spacecraft.
- A parabolic antenna, with AZ/EL rotator, to receive the S-band transmission from the satellite and to uplink the L-band replies to the spacecraft.
- VHF and UHF Yagi antennas, with a common AZ/EL rotator.
- Software for automatically tracking the spacecraft, using updated orbital elements, which could be conveyed to all ground stations utilizing this same digital link.

Note: A common Az/El rotator for both items 6 & 7 is being studied.

Present Status of Project CESAR

The construction of CESAR-1 is proceeding at a pace slower than anticipated. The main problem is the natural difficulty of being confronted with many different problems for the first time, so we may summarize the present status of the project by saying *it is finally getting off the ground.*

What progress have we made?:

- We have an almost completely equipped lab at Quinta Normal, Santiago, where we meet and work during all weekends and other days in the week. Also a fully equipped amateur radio satellite receiving and transmitting station at that location: CE3SSA has been set up and it is fully operational and communicating through the existing Amateur Radio satellites.
- We have already bought all of the aluminum to build the structure of five microsats. (A group of professors and students of the Universidad de Santiago will numerically machine the large pieces of the spacecraft structure). Also, all magnets and hysteresis damping bars, and most of the electronic components have been purchased.
- A group of hams and professors at the Universidad de la Frontera have already built their version of the V40 computer, based on

the printed circuit board that Alberto Zagni, I2KBD, gave us.

- We have purchased one hundred regular, non-space grade, NiCd batteries which will be fully tested under (an already developed) computer control for selecting the best to go through the vacuum test and then store them in a refrigerator until needed for the first flight unit. The computer, the special test pc board and the computer program are almost ready.
- Software-wise we have finally obtained all of the modules listed in the software map provided by Harold Price, NK6K.

There are many pending problems and items to be resolved; among them, the solar panels; the understanding and testing of all of the on-board software; the financial resources we need to continue at least at the same pace, etc., etc., but these shall not stop us from trying and from keeping an optimistic attitude on these efforts we are committed to exercise till the first spacecraft becomes fully operational and in orbit.

Acknowledgements

The colleague who has had the most influence on this group of Chilean hams is Dr. Thomas Clark, W3IWI, who came to Chile in November 1991 and convinced us that building a microsat was a real and feasible project. Then in 1992 we had the visit of David Lieberman, XE1TU, who was building UNAMSAT-1 at that time; his visit in turn triggered visits of two of us to him in Mexico to start learning the trade secrets of microsat construction. The presence of colleagues, such as Alberto Zagni, I2KBD, who during four days in 1994 shared his data and experience with us, was really of tremendous value. His lessons were particularly useful to understand what it takes to initiate a microsat project. Another very fruitful visit was that of Lyle Johnson, WA7GXD.

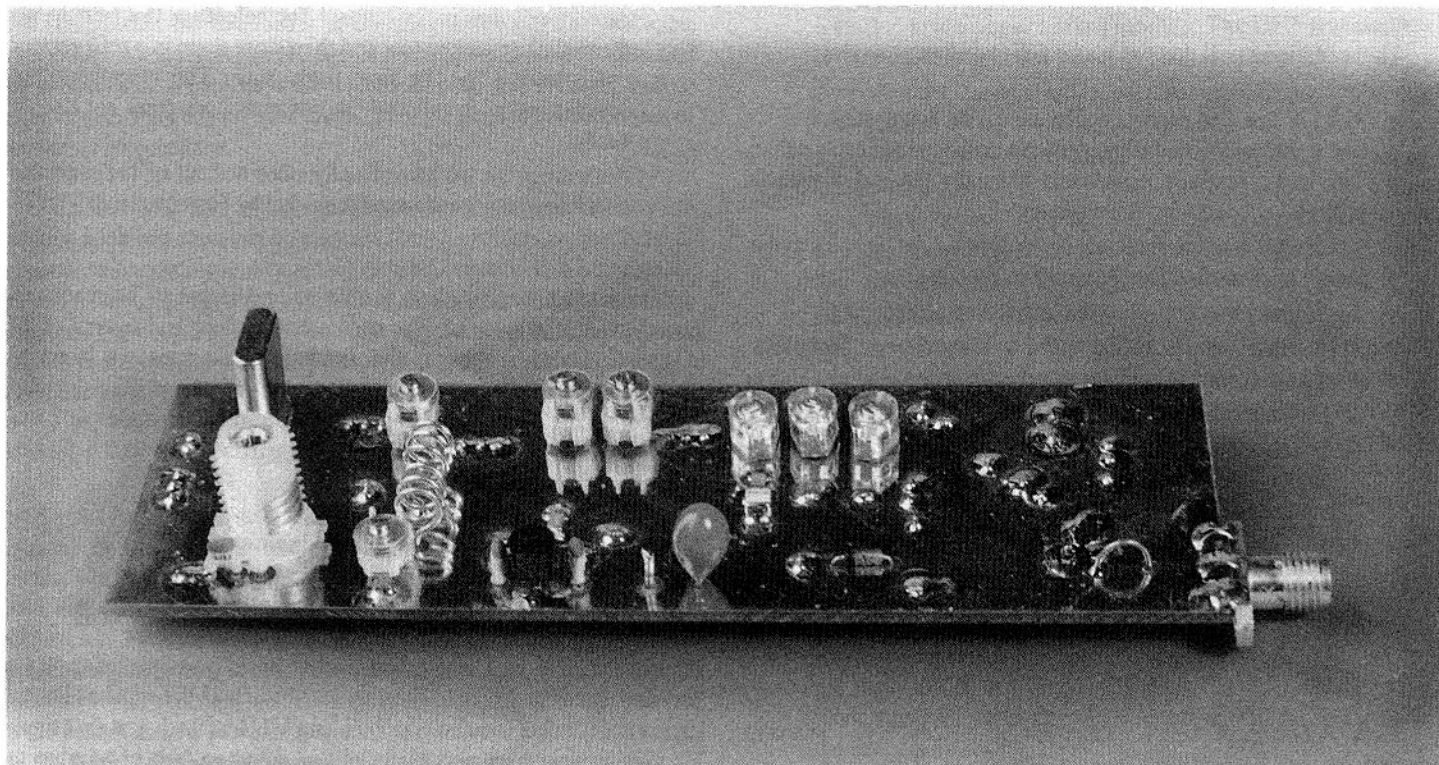
We realize that it is taking more time to build the first spacecraft than we initially thought; however, we are becoming more confident on our achieving the goal we set out, since we are seeing already-built parts of CESAR-1, the active participation of more colleagues and non-colleagues, and the interest of industry CEOs



AMSAT-NA President Bill Tynan W3XO, presenting ARRL Vice President Joel Harrison, WB5IGF with a plaque at the recent AMSAT Banquet in Tucson, AZ. AMSAT has dedicated the Phase 3D spaceframe in recognition for ARRL's continual contribution and support of the Phase 3D project. (KC5JVB photo)

An S-Band to 70cm Receive Converter for Phase 3D

by David Bowman G0MRF



General view of the completed PCB.

Editor's Note: This circuit was originally outlined in a presentation at the 1996 AMSAT-UK Colloquium held at the University of Surrey and printed in the October 1996 issue of AMSAT-UK's Oscar News.

A recent survey of satellite users world-wide revealed that only 3 percent were active on mode S. With the re-entry of Oscar 13, we will have now sadly seen the end of a mode S transponder that has given years of reliable service and to one of the most appreciated and successful experiments to be carried on an amateur satellite. For this 3 percent, operating mode S meant working at the cutting edge of satellite communications. It is well to remember that the S band transmitter on AO-13 was usually run at a power of less than 1 Watt into its small 8 turn helix. When working mode S on AO-13 a typical receive station could consist of a small 0.6 metre dish but with a high performance receive converter having a noise figure of around 0.6dB. With this system it was very easy to receive the satellite's signals over distances of 35,000 km.

With Phase 3D, the S band transmitter will operate at powers in excess of 40 Watts and with an antenna gain at least 6dB or four times greater than Oscar 13. The receive converter described here, together with a small helix around 18 inches long, will give excellent results with the new satellite.

Design Objectives

This project has been designed for home construction, with performance only one of several considerations. These include:

- System Noise figure of less than 2.0dB
- Conversion gain of 20dB
- Low cost consistent with ease of construction
- One PCB with low component count
- Robust and easy to reproduce
- Easy to align. i.e. No complicated test equipment and less than 15 minutes!

The final result of this process has been to produce a receive converter which I believe meets the design criteria. Testing of a prototype on a Hewlett Packard 8970A Noise Figure meter showed a System noise figure of 1.85dB with a conversion gain of 32dB.

Modern Microwave Components

The last few years have seen a rapid growth in UHF and microwave telecommunications. The expansion of this industry, which is rightly seen as a threat to our amateur allocations, has also led to the development and mass production of some very useful RF devices. The trend in current microwave design is to use components that are internally impedance-matched to 50 Ohms. Our circuit maximises the use of these easy to use and reliable *building blocks*. Gain is provided by Monolithic Microwave Integrated Circuits (MMICs). The mixer used has Schottky diodes and matching transformers mounted inside its ceramic case and the filter has four connections: input, output and two to ground. A degree in plumbing is definitely not required!

The first amplifier used at the antenna input largely determines the overall sensitivity of a receiver. The Low Noise Amplifier

(LNA) used here was introduced by Hewlett-Packard in 1996. The MGA86563 is a high gain LNA usable within the 500 MHz to 6 GHz frequency range. It is a 3 stage GaAs FET MMIC constructed using *State of the Art PHEMT technology*. The device requires a nominal 5 Volt supply at 14 mA, but unlike other similar products, can operate from higher voltages thanks to an internal bias regulator.

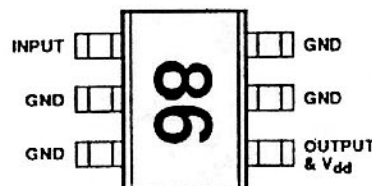
The converter is constructed on a standard 62mil (1.58mm) double sided FR4 fibreglass PCB. While this material is not the best choice for use at this frequency, it is more robust and easier to handle than boards using very thin PTFE substrates.

I also decided early on in the project to use surface mount components. I realize that this may discourage some potential constructors but there are two indisputable reasons for doing so. First, I found that the Local Oscillator section could be built using four transistors using Surface Mount Devices (SMD) but needed an extra stage if I used conventional components. Second, there are many opportunities for leaded components to be incorrectly inserted in the PCB. Long wires usually equal a non-functioning circuit at S band. With a surface mount component, if it's in the right place and soldered correctly, then it will work. As a compromise, I have used large SMD for ease of handling.

Circuit Description

The Local Oscillator is based on an excellent design by Sam Jewell G4DDK. Sam's original circuit has been adapted in this application for surface mount construction and optimised for a frequency range of approximately 1700 to 2000 MHz. Crystal X1 is a 5th overtone unit with a frequency of 109.333 MHz. Transistors TR1 and TR2 form a Butler oscillator with L1/C1 tuned to the crystal frequency. The output at the collector of limiting amplifier TR2 contains a high level of harmonics and tuned circuits L2/VC1 and L3/VC2 select the third harmonic at 328 MHz. TR1 and the base of TR2 operate from a 9 Volt supply produced by a 100mA voltage regulator IC5. TR3 is a frequency multiplier which triples the frequency from 328 to 984 MHz. The input is coupled to the base of TR3 by C10. The value of C10 is only 4.7pF which allows enough signal through to drive TR3, but is small enough in value not to degrade the Q factor of L3/VC2, and to provide some rejection of any residual 109 MHz. R9 provides a constant load for the drive and sets the bias point for TR3 ensuring the generation of harmonics.

The output of TR3 is a two stage bandpass filter constructed using microstrip techniques. Z1 and Z2 are



Pin connections and packaging marking. Note: Packaging marking provides orientation and identification.

inductively coupled, shortened quarter wavelength lines, etched onto the printed circuit board. Each line is tuned by a variable capacitor (the high impedance end) and is AC-coupled to ground at the other (low impedance) end. The transistor is impedance-matched into the filter simply by tapping onto Z1 at the appropriate point.

Component List

*** = Located on groundplane side of PCB**

Semiconductors

* IC1	MGA86563 - (H.P.)	* IC5	78L09
IC2	MAR6 - Mini Circuits	TR1 TR2	PMBTH10 - Philips
IC3	RMS30 mixer	TR3 TR4	BFR93A - Philips
IC4	MAR3 - Mini Circuits	* ZD1	5V6 400 mW

Inductors

* L1	4.5 turn Toko S18 with Aluminium core
* L2 L3	3 turns 22 SWG tinned copper. 4mm inside diameter. 2.5mm off PCB.
* L4	22 SWG tinned copper formed into U shape with I.D 4mm. 5mm high
L5	Toko SM inductor 150nH type 32CS

Capacitors

C1, 6, 7	22pF	* C4, 8, 9	4.7nf plate ceramic
C2, 5, 11, 16, 17, 19, 20,	1nF	* C12, 15	1nF
C21, 24, 27, 29, 30	1nF	C22, 28	0.1uF
C3, 23, 25	27pF (0805)	* C26	10uF Tant
C10, 13	4.7pF	* VC5, 6, 7	Sky 0.5 - 5pF
C14, 18	12pF Porcelain ATC 0.1 inch		
* VC1, 2, 3, 4	10pF film trimmer, 5mm dia. (Philips)		

Resistors (1206)

R1, 3, 6	1kΩ	R11	22Ω
R2	820Ω	R10, 13, 15	47Ω
R4, 5, 8	470Ω	R16	680Ω
R7, 14, 21	10Ω	R17, 19	330Ω
R9, 12	2.2kΩ	R18	18Ω
R20	220Ω		

Miscellaneous

F1	Toko chip dielectric filter.	TDF2A-2450-10
X1	Crystal 109.333 MHz HC18U series resonant	
Printed Circuit Board with etched microstrip elements. 108 x 36 mm.		

The final stage in the Local Oscillator is a frequency doubler, from 984 to the output frequency of 1968 MHz. The input is coupled to the base of TR4 by C13. The transistor is biased to class B by applying approximately 0.6 Volts to the base produced by potential divider R11, R12. The collector supply is fed to the transistor via stripline Z4 with RF decoupling performed by C14 and C15. During development I found that the standard 1nF chip capacitors were not very effective at decoupling frequencies above 1GHz. The addition of the porcelain American Technical Ceramics capacitor C14 increased power output by 50 percent. A further increase was achieved by including the quarterwave high impedance transmission line Z3.

The output at 1968 MHz is taken from the collector and applied to another microstrip bandpass filter. A three section filter was selected to allow effective filtering of the local oscillator. Any spurious signals will cause unwanted products to appear at the output of the converter. The filter, Z4 Z5 and Z6, provides a clean output of 5mW with unwanted products suppressed by at least 42dB. Each stripline is tuned by a variable capacitor as in the previous stage, but here the type of trimmer chosen is important. The green SKY trimmers (1) specified have a maximum value of 5pF, but more importantly, have a minimum capacitance of only 0.5pF. Any substitute should have a minimum capacitance of not greater than 0.75pF. This will limit the choice to foil or ceramic types which are physically small, or to piston trimmers as marketed by Down East Microwave in New Jersey.

The RF Section

The entire RF section is constructed from modern 50 Ohm block components. The amplifiers, filter and mixer are all internally matched to 50 Ohms and consequently there are no adjustments to be made. The broadband characteristics of the devices used mean that this converter receives all frequencies from 2400 to 2500 MHz and converts them to 432 to 532 MHz.

The input at 2400 MHz is passed via a low loss ATC capacitor C18 and matching inductor L4 to the L.N.A. IC1. Supplying voltage to the LNA requires care as it is only conditionally stable at some frequencies. My final solution was to use RF choke L5 with a series

resistor R15 to reduce the Q and ensure stability. Zener diode ZD1 drops the 12 Volt supply to 6.4 Volts which is within the limits of IC1. The LNA output feeds bandpass filter F1. This filter has a bandwidth of 100 MHz and is manufactured from the same type of ceramics technology found in dielectric resonant oscillators. The centre frequency is 2450 MHz providing an ideal response for S band satellite operation. The manufacturer's data sheet shows a mid-band insertion loss of 1.16 dB with a L.O. rejection of -35dB. Image frequency rejection is off the graph supplied by Toko but in reality is likely to be limited by coupling between PCB tracks. IC2 is a standard MAR6 MMIC which has a gain of 10dB and a noise figure of 4dB. This feeds a Mini Circuits RMS30 double balanced mixer. The RMS30 is specified to 3 GHz and has internal matching on all ports. The output is taken from the I.F. port to a -3dB resistive attenuator. This was included because the input of the 432 MHz amplifier IC3 may not be 50 Ohms at all frequencies emerging from the mixer.

Construction and Testing

The PCB is double sided, with the topside used as a groundplane for all earth-grounded connections. Some components are mounted on the GP side and these are identified in the parts list. The trackside layout with its component overlay is presented in Fig.2. If you plan to mount the PCB into one of the popular tin plate boxes (1) trim it to size before you fit the components. Any flexing of the PCB after assembly may crack the surface mount devices.

Start the assembly process by identifying and soldering all the through-board earth-grounded connections. These can be formed by cutting short lengths of 24 SWG tinned copper wire and then bending 2 -3 mm at 90 degrees. These are inserted into the groundplane side and soldered. Then, turn the board over, solder the links on the track side and cut off the excess wire. The components can be fitted in any order, but leave the LNA and L4 until last. The best results are obtained using a minimum quantity of solder. If you use too much, the excess can be removed with desolder braid.

The LNA is only manufactured in a miniature SM package. I found that it can be soldered successfully if you hold it in the correct position and then solder one of its ground connections. With the device in place, look very carefully at its position. If it's not correct then reheat the joint and move the device. When you are totally satisfied that the LNA is in the right place, solder the remaining five leads. It is almost impossible to reposition the device once all six leads have been soldered.

The alignment process is in two stages. You will need an analogue multimeter, a 70cm receiver and a 2.4 GHz signal source - more on this later. Start by pre-setting the variable components as follows. Adjust the core of L1 to be level with the top of the former and then turn the core into the former by another 2 full turns. Set VC1/2 to be 40 percent meshed VC3/4 to 15 percent meshed and VC5, 6 and 7 to be 5 percent meshed. Support the board off the work surface so that the microstrip lines are not detuned and connect 12 Volts. The current should be 60-70mA before tuning and about 130mA when alignment is complete. First, check that the crystal is oscillating by listening for the fourth harmonic near 438 MHz on the 70 cm receiver. If no signal can be heard, then adjust L1. With the oscillator running we can now align the three

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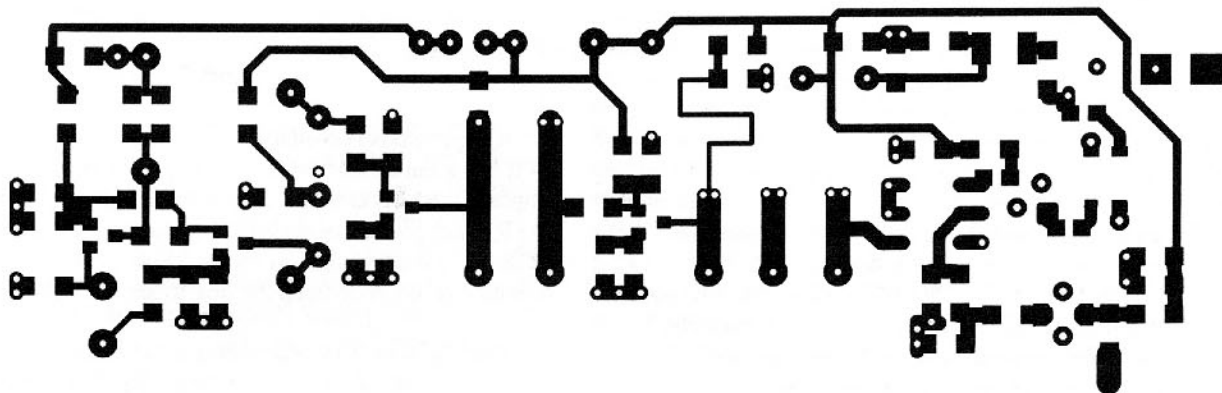
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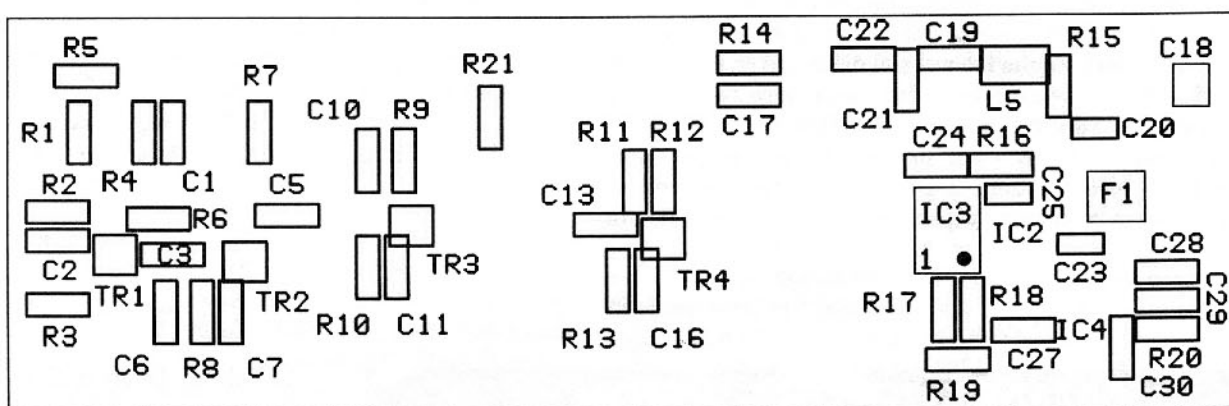
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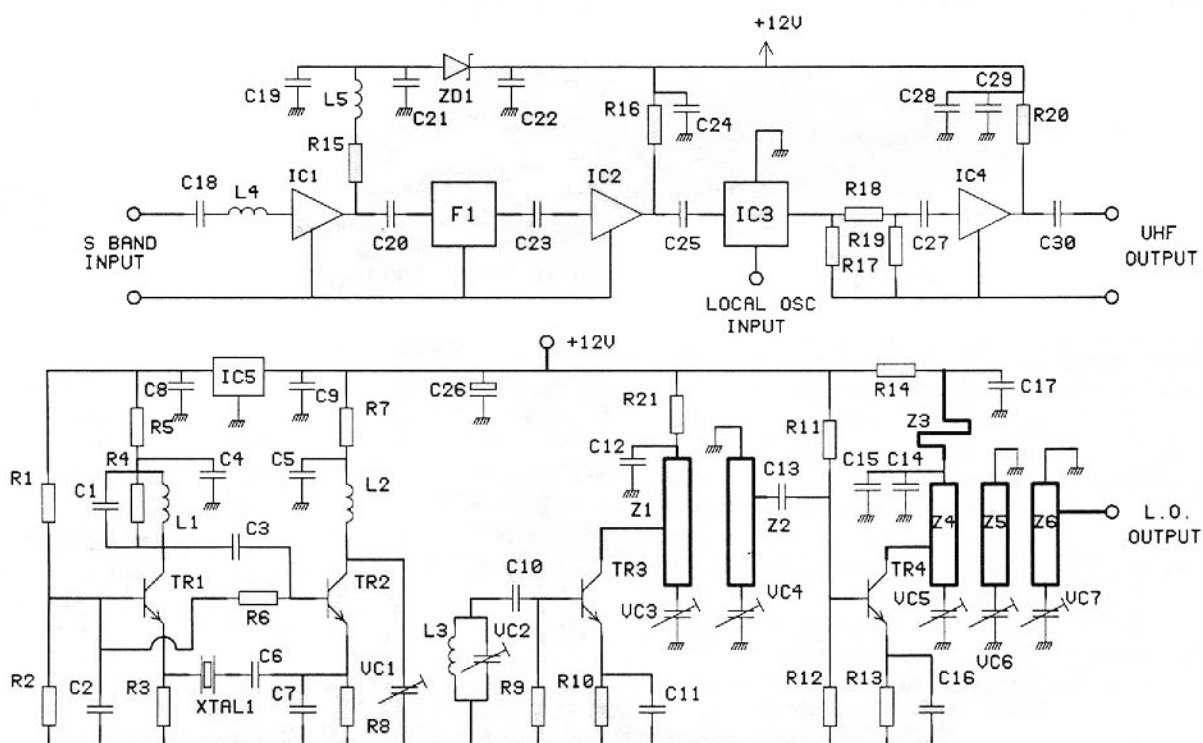
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Printed Circuit Board (PCB) Track Layout (1.5:1 scale)



Trackside Component Overlay (1.5:1 scale)



S-Band circuit diagram (drawing by David Bowman, G0MRF)

multiplier stages. Set the meter to read 1 Volt full scale and place the probe on the emitter of TR3. With no drive, the Voltage will be zero. Using a trim tool, adjust VC1 and VC2. As you tune the circuits to 328 MHz, TR3 will begin to conduct. Just tune for maximum emitter voltage - it's as simple as that! Next, move the meter probe to the emitter of TR4. The voltage should be around 100mV due to the bias resistors on the base. Repeat the tuning process, this time adjusting VC3 and VC4 to give maximum emitter voltage. When correctly tuned, the voltage should increase to over 750mV. One word of caution is necessary here. TR3 is designed as a frequency tripler from 328 to 984 MHz. However, it is possible to tune the striplines to 656 MHz by mistake. Fortunately, this is fairly obvious as the trimmers will be 50 percent meshed at that frequency. The alignment process for the final doubler is a little different, as we have now run out of emitters! To adjust the last stage, connect an antenna to the converter's input and your 70cm rig to the IF output. At this point, you'll need to generate a weak test signal on 2400 MHz. The AMSAT-UK signal source (2) is ideal but your S band converter is very sensitive and will easily pick up a harmonic from a VHF / UHF source. Failing that, a few hundred milliwatts of 28 MHz applied to a signal diode and series 50 Ohm resistor will suffice. Place the test source 6 feet away, switch on the receiver and select SSB. As you apply 12 Volts to the converter the noise level from the receiver will increase. Locate the test signal and note the S meter reading. The final three trimmers will all resonate close to minimum capacitance. Adjust each one for

maximum S meter reading. This indicates minimum conversion loss in the mixer and completes the alignment.

And Finally.....

A tinfoil box is available for the converter and is recommended as it has a removable lid and base, giving excellent access. Being tinfoil, the PCB can be soldered to the sides of the box along with the RF and power connectors. An alternative solution is to fit the PCB into a diecast aluminium enclosure. This will be much easier to waterproof but do keep the box as small as practical.

The finished converter should be installed as close to the antenna as possible, as coaxial cables have very high losses at 2.4 GHz. The I.F. output at 70cm can, however, be run back to the shack via long lengths of cable without problem. Because the gain of the converter is 32dB, the coaxial cable can lose up to 10dB without noticeably affecting overall performance. Finally, as most units will be mounted outdoors, local oscillator stability should be mentioned. The L.O. frequency can be measured at all times by listening to the crystal's 4th harmonic on 438MHz. In most cases any drift in the L.O. will be minimal compared to the Doppler shift from the satellite. However, a small 12 V clip-on crystal heater is available (3) and will hold the frequency to better than 1 kHz during cold weather.

Notes

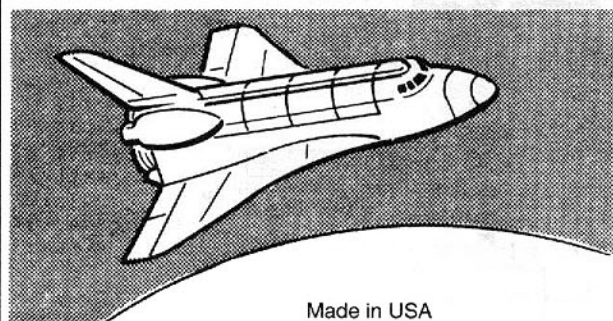
1) Tinfoil boxes model 7754 and 5pF SKY trimmers are distributed in the UK by Piper Communications. 4, Severn Road, Chilton, Didcot, Oxfordshire, OX11 0PW, United Kingdom. Telephone: 01235 834328.

2) "A Low Cost Signal Source for 2.4 GHz," *AMSAT-UK OSCAR News*, No 112, April 1995.

3) Crystal heaters / Sky trimmers. - RSGB Microwave Component Service, c/o Ms. P. Suckling. 314a Newton Road, Rushden, Northants. NN10 0SY, United Kingdom.

Editor's Note: If there is sufficient interest in this project it is possible that a kit of parts may be available at some time in the near future. Present David is pricing a complete kit for AMSAT-UK. Please address any queries to David Bowman, G0MRF, 31 Benson Close, Hounslow, Middlesex, TW3 3QX, England. Telephone or fax: 011-181-572-8615 or 011-123-583-4328. ■

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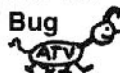
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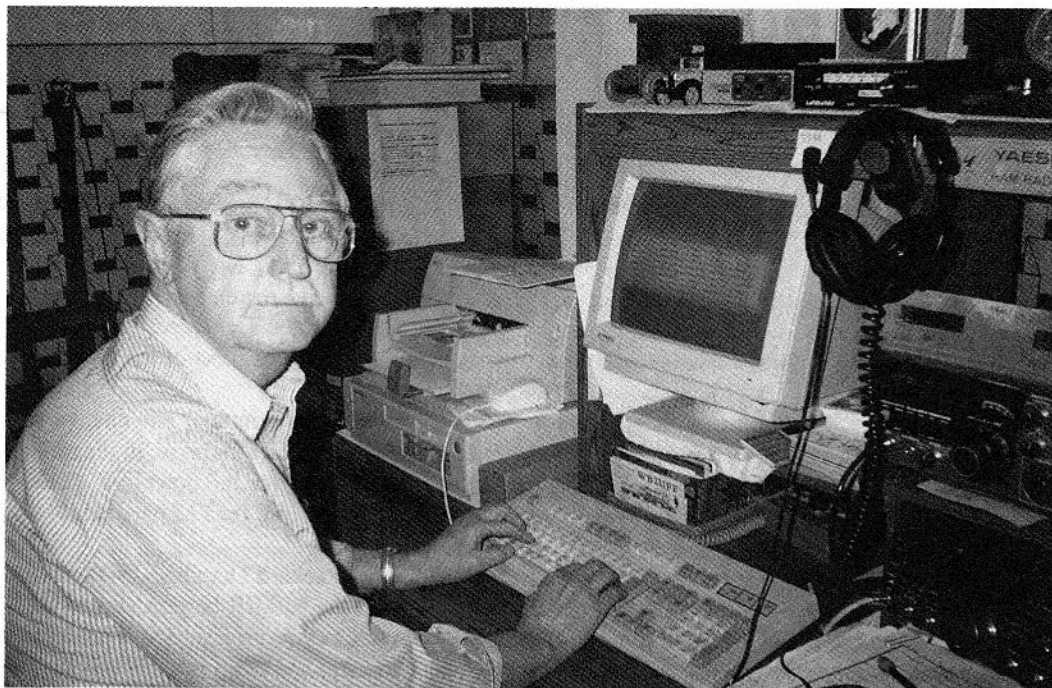
Frank Cahoy, K0BLT (k0blt@amsat.org)

Why would anyone title an article about Amateur Radio satellites *A Voice Crying in the Desert*? I am sure we have all heard or read that phrase many times. It is what most often occurs to me when I attempt to work RS-15. Strangely enough there is one voice I hear ever so clearly. Unfortunately, it is my own downlink. I also work RS-10/11, the other Mode A satellite. I have heard time and time again that the beacon and downlink signals from RS-15 are just too weak to copy. If you are using the same Ringo Ranger on 2-meters up and the same 10-meter dipole down I would certainly have to agree. You will probably not hear RS-15. The transponder on board this bird is running very, very, low power (about 4/10 of a watt). At the same time, the antennas on RS-15 are not always oriented towards Earth. As a matter of fact, the satellite is tumbling, although not as nearly as rapidly as when it was first launched. There is no doubt whatsoever that RS-15 is a *strange bird*. On the other hand, it is a most reliable communication device. I have personally worked this satellite since the transponder was first activated in early 1995. There are eight passes a day at about two-hour intervals. I assure you that RS-15 can be worked from AOS until LOS with about 90 percent copy. There are always varied amounts of QSB present. With patience and persistence a most enjoyable twenty minute *ragchew* is quite possible. Disappointingly living in Bridgeport, Nebraska does not allow me a very long European window. Nevertheless, I have managed QSOs with Poland (SP1NQN) and Slovakia (OM3MM) and a number of western Europeans. In particular, I have worked Dave Rowan, G4CUO at least 150 times. Not only that but Dave has traveled to GD, GW, and GM and we have worked from his portable QTH with very Q5 signals both ways. This proves conclusively that RS-15 is a useful satellite. Please do not turn your nose up just because it is a Mode A bird. I just had a quick check of my satellite logbook and I surprised myself as I have logged about 950 RS-15 QSOs. My LEO satellite countries total is 59 in about 2½ years. I would never thought I would have the patience and *stick-to-itiveness* for such a growing country list. In the not too distant past, I have worked DXCC in a single contest weekend on the HF bands!

Having said all of the above, I still sense a lot of doubt out there. I can assure you all that I do not have a state-of-the-art satellite station. As of August 1996, I worked only three (RS) satellites. My station consists of my HF tri-band beam (Hy-Gain TH5) up at fifty feet and a Yaesu FT-890 transceiver. This is my Mode A downlink with the addition of a 10-meter pre-amp. The 2-meter uplink is an old Kenwood TS-700A, a Mirage B108 to either a 4-element Yagi

(permanently mounted at 30 degrees elevation) or a 13-element Yagi pointed directly at the horizon. All three Yagis are mounted horizontally on the same tower and all are tuned with a common rotator. I use no elevation rotator whatsoever. The little 4-element Yagi plays quite well on the high passes (+20 degrees) while the 13-element Yagi plays well when the bird is 20 degrees or lower which is the case when my European window opens. I use a remote antenna switch for 2-meters thereby using a common piece of 9913 coax. I have a very long run (+100 feet) so I calculate that nearly one half of the 80 watts out of the amplifier is lost before it reaches the 2-meter antenna. I have a perplexing problem of hearing stations much better than I can be heard in return. A very depressing incident is to hear a new DX country calling CQ with a perfect Q5 downlink signal and then have him call another CQ right on top of my answer to him. With a naturally weak downlink signal from RS-15, I am convinced that a gain antenna and a receive pre-amp are nearly essential to consistently work this bird. It is relatively easy to get a 2-meter uplink signal into the satellite. However, you really need great sensitivity and lots of gain on that downlink signal.

I would implore Mode B operators to give RS-15 a fair shake. It is a challenging satellite to try and work. However, it is there day-after-day with a number of good passes covering many interesting places of the world. I know there is Mode B activity from all of the world that is mutually accessible via RS-15 and stateside in general. A classic example is the fact that I personally have a four to five minute window with Northern Japan and yet in all of the hours I have spent listening and calling CQ JA, I have never heard a single Japanese station on RS-15. The same can be said of the northern half of South America and Africa. All of these areas of the world have a mutual window with much of North America. There is pass after pass where I hear not a single whisper of a signal save

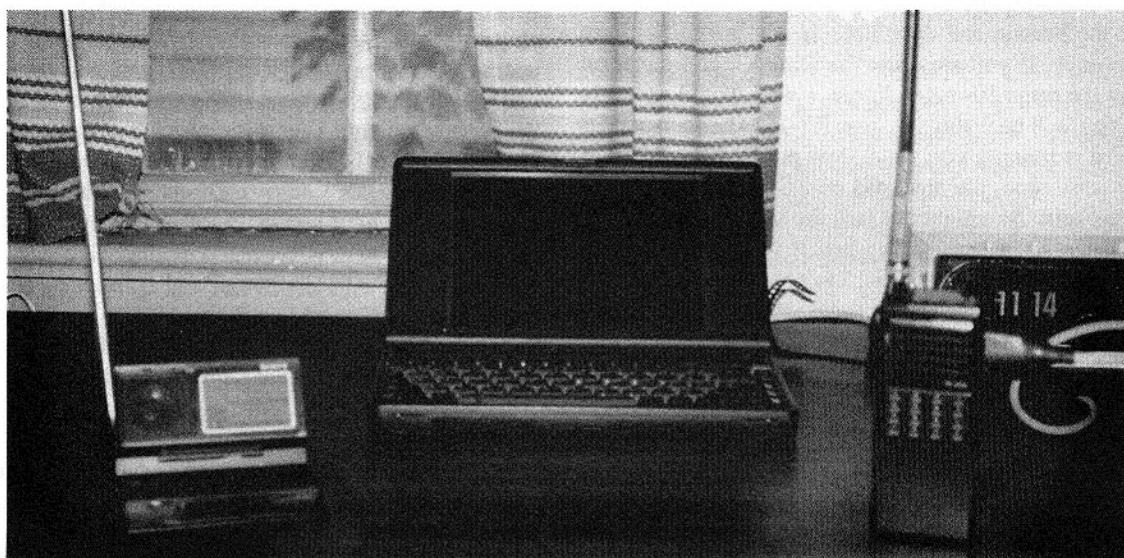


The author at his QTH in Bridgeport, Nebraska.

for my own downlink calling CQ. I can access RS-15 a few seconds after AOS and work or hear it myself until my computer indicates LOS. I fully realize that an RS-15 pass is less than 30 minutes but it can be such a fun time if only there were someone to talk to. Keep in mind that with such a limited amount of access time, it is wise to try and get into the bird from the first moment you hear the beacon. It is not like the high fliers with several hours of usable time. You must make good use of every minute of the time available, particularly if you live west of the Mississippi. For those

of you in countries outside of North America it is very important to get up on the bird the moment you are able to hear your own downlink. Keep in mind that if you wait until the satellite is up and well into the pass, we on this side may have already reached LOS.

Editor's Note: Frank invites readers to contact him if you would like to set a satellite schedule. He calls CQ on RS-15 on or about 29.390 MHz SSB and 29.365 MHz CW. ■



The World's Smallest Satellite Station? Ray Soifer, W2RS

The accompanying photograph shows my candidate for *the world's smallest working satellite station*. The two-meter uplink consists of a Kenwood TH-26AT handheld transceiver and an AEA *Hot Rod* half-wave whip antenna (right foreground). For the ten-meter receiver, it uses a Sony SW-100E miniature portable shortwave receiver, with its collapsible whip antenna (left foreground), which was purchased originally for use as a travel alarm-clock radio.

As an experiment, I tried using this *micro-station* to work through RS-10/11. On August 8, 1996, I heard Roger Jeanfaivre, K1QPM, calling CQ and worked him on CW, on the first call, by keying the TH-26A PTT button while waving the hand-held around to produce the best downlink signal in the SW-100E. My two-watt EIRP produced a single report from Roger of 559, which was a bit generous with respect to the tone!

Since the initial contact I have put the micro-station on four RS-10/11 passes and worked three more stations, including a new DX record (for it) of Marvin Crawford, K5AHE in Louisiana. On the fourth pass, someone (Stan Brigham, W3TFA) actually came back to my CQ, but there was so much QRM that we could not complete the QSO. No, you probably can't make DXCC with it, but it's proven to me that it is a real satellite station. Especially on passes of 20 degrees elevation or more that are not overcrowded, it has been a consistent QSO maker. On RS-15, I can hear my 2-watt uplink at times on a real receiver with a real antenna, but the satellite's downlink is just too weak for the little SW-100E to copy anything except the beacon most of the time.

That tells me that if someone has a 25-watt FM radio and a simple outdoor antenna, he should be able to do quite well through RS-10/11 even with an inexpensive receiver. But then, that should not be a surprise; in the mid-1970s I worked 49 states on OSCAR 6 running about 35 watts output from a TX-62 and an ancient KWM-2 for the downlink. (KH6 was out of range until the RS's were launched.) The tone was, I must admit, better than the T7C that I get from the FM handheld!

The notebook computer in the center background, a Hewlett-Packard Omnibook 300, was not involved in the K1QPM RS-10/11 QSO, except to predict the pass times. It has, however, worked the R0MIR beacon aboard the Mir space station, and copied packets from DOVE and SAREX, operating through the TH-26AT with a Baycom BayMod-9 modem (the one that comes packaged within a 9-pin *gender-changer* plug). The connecting cable between modem and radio is visible in the photograph. Incidentally, the equipment in this photograph is also used for portable packet operation throughout the U.S. and U.K. as W2RS and G0W2RS. To answer the obvious question, no, I haven't yet tried it on EME! ■

Field Ops Update: Publicizing AMSAT and the Easy Sats

Barry Baines, WD4ASW (wd4asw@amsat.org)

In the September/October issue of *The AMSAT Journal*, did you notice the comment in the BoD minutes regarding AMSAT membership? The minutes state that AMSAT membership remains near 7,000 with the renewal rate more impressive than the gain in new members. This means that there is a good probability that once an individual joins AMSAT, that person will continue to renew their membership. So we are doing a pretty good job of maintaining our membership's interest in the satellite program once people become interested in satellites in the first place.

The above statement also suggests that our ability to attract *new* memberships has declined somewhat during this period as well. That is, AMSAT has been unable to get as many people to join AMSAT as we would expect. In fact, the minutes suggest that the Board has decided to emphasize revenue sources other than new memberships by *reducing* membership solicitations in Amateur Radio journals. Outside interest appears to be waning. The BoD minutes provide several possible explanations, including the *lack of satellite launches* as the most probable cause.

Keep in mind that the BoD meeting was held on June 29, prior to the launch of JAS-2/FO-29 and UNAMSAT/MO-30. I do not know if these recent events have increased general interest over what was experienced in the past. I suspect that their impact, if any, is directly related to the interest generated by local AMSAT members and their ability to inform and build excitement within their respective local amateur communities.

Recent messages on AMSAT-BB have mentioned steps that AMSAT members can take to help build *public awareness* of what amateurs can do to work the satellites. A great example is Mir, where we have enjoyed unparalleled use of Amateur Radio by three American residents: Norm Thagard, Shannon Lucid, and John Blaha. Mir has been active with Amateur Radio since 1988, when the first Amateur Radio ground-to-Mir contact from the US was made during the AMSAT Symposium in Atlanta, GA. The fact that Amateur Radio is now being extensively used by Mir

(which increases the probability of hearing the cosmonauts/astronauts) and that it is currently possible to watch the Mir spacecraft cross the horizon at sunrise/sunset can do much to generate interest if AMSAT members will take the time to let their local clubs know what is happening.

An excellent mechanism is the use of the local repeater to announce the arrival of Mir when it is overhead, whether or not it is currently viewable, and whether Mir is currently on 145.800 MHz will certainly generate local interest. Make the effort to let others know *what's happening!*

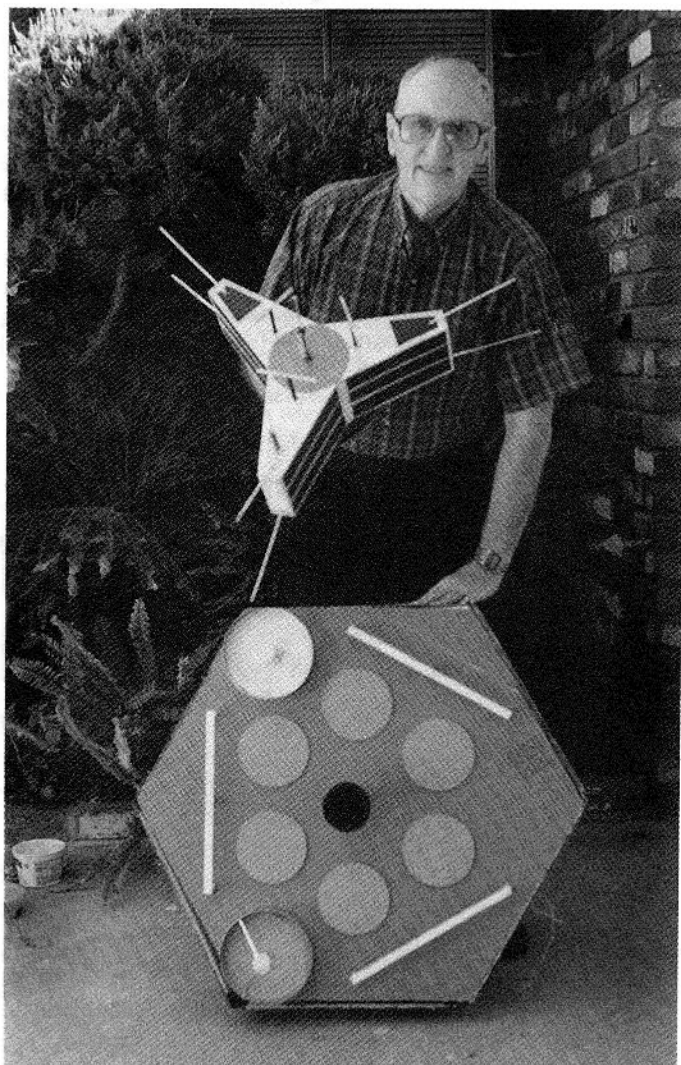
A second vehicle for consideration is AO-27, with its FM capability on two meters and 70 centimeters. When the satellite is overhead, publicize the fact that the satellite can be heard on 435.800 MHz. If we can take the time to publicize when this satellite is in the neighborhood and that it is possible to work this bird with a dualband radio, we can do much to build interest in satellites and AMSAT.

Even JAS-2/FO-29 offers some interest to people with limited resources. A digitalker capability on 435.910 MHz FM offers some interesting possibilities to those who want to listen and not necessarily generate a two-way contact.

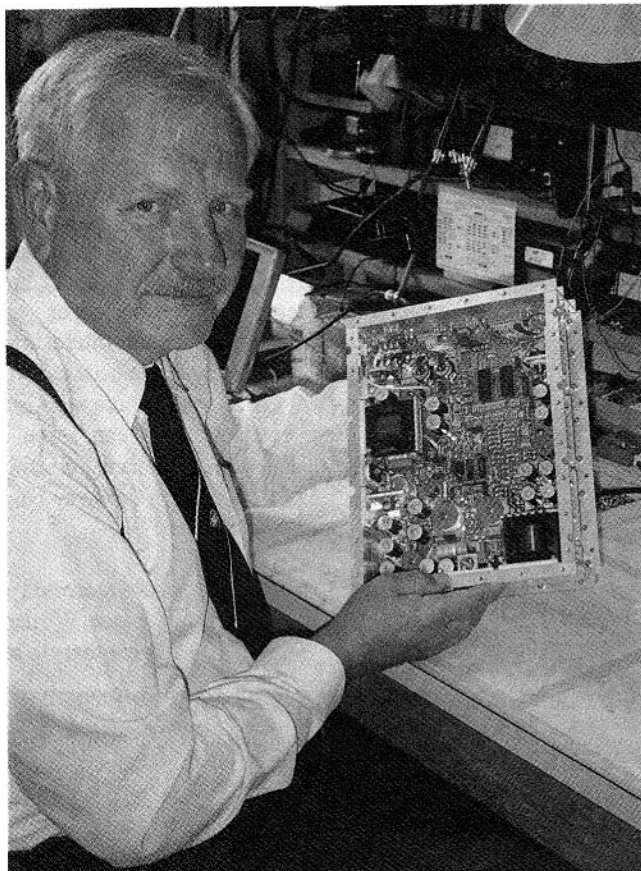
The bottom line is that it is up to our AMSAT membership to help build local general

interest in the amateur satellite program which in turn helps to recruit new members. Talk about what it is that attracts *you* to the satellite program and what you *do* with satellites! Are your interests in analog and/or digital? If analog, think about how you can share your experiences and excitement with others. If your interests are in the digital modes, evaluate how can you share your data/files with others who may want to see how satellites can serve as orbiting bulletin boards. Ever consider establishment of a Satellite Gateway Node for your local packet group?

The key is to get folks interested in amateur satellites in the first place. We need to share our excitement and get others to see



Clair Cessna, K6LG with his homebuilt 1/3 scale mockups of AO-13 and Phase 3D. Made of styrofoam, they have been used to make a video on how to work OSCARS that has been presented to Amateur Radio clubs in Southern California. Clair notes he has placed AO-13 on a record turntable at 33 1/3 rpm to simulate rotation!



Dr. Andras (Bandi) Gschwindt, HA5WH, proudly displays Phase 3D's Battery Charge Regulator (BCR) at the Marburg Phase 3D Lab. The BCR will control all of Phase 3D's onboard power activity such as regulating battery charging from the solar panels. The BCR was built by Bandi's his team at the Technical University of Budapest, Hungary. (AMSAT-NA photo by Keith Baker, KB1SF)

what amateur satellites have to offer. If indeed we can encourage members of our local amateur communities to become strongly motivated toward learning more, then it is much easier to convince them to join AMSAT. We will have successfully recruited new (and hopefully renewing) members.

Once we have people interested in learning more about satellites, it is also incumbent upon us to help get them 'educated' about working amateur satellites. In the last issue of *The AMSAT Journal*, I mentioned the growing trend toward satellite workshops where AMSAT members can make detailed presentations (and demonstrations) concerning satellite communications. The key again, of course, is to generate enough interest within an individual that

the amateur is willing to sit through a comprehensive seminar. It is very important that as these workshops are planned and announced, that we help to publicize them and get local amateurs to reserve a seat for these presentations. As workshops are planned, they will be publicized by the sponsoring organization (such as a hamfest committee) as well as AMSAT/ARRL as appropriate. I expect that AMSAT-BB will also be one vehicle for getting the word out on such workshops.

In summary, our ability to attract new members is probably more dependent upon how effective we are in having local AMSAT members publicize the amateur satellite service than by ads in amateur radio magazines, the generic publicity of recent launches, or even discussions about Phase 3D. It is the personal touch, the enthusiasm generated by our own membership, that will encourage others to look upon space communications for its possibilities. For many, the excitement of a first contact with Mir will be an unforgettable experience no matter how long the station has been in orbit. It is extremely important that we all consider ourselves to be *Ambassadors of AMSAT* and that we make the effort to let others know the opportunities that await amateurs who become involved with the amateur satellite program and to encourage them to take the first steps. ■



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N8ULU Satellite Gateway

by Jerry Smyth, N8ULU (n8ulu@amsat.org)
<http://www.wwnet.com/~jsmyth>

I remember when I first was licensed in June of 1992, reading the Space Operations chapter in my newly acquired ARRL Handbook. While reading this chapter, I ran across a diagram of an HT being used through a satellite gateway system. I thought "Wow, you can talk through a satellite with an HT? That's cool!"

I got started in satellite operations by joining the Henry Ford Community College ARC (K8EEH). They had a satellite station so I signed up. A couple of the guys, Mike Rudzki, KF8BE and Mike Anderson, N8MVP started showing me the ins and outs of satellite operations. I asked them, "Have you guys ever heard a satellite gateway station?" They said "Nope, never heard one." Well, that thought was shuffled back into the file. Since then I have never heard anyone talk about an analog satellite gateway on the satellites. I had seen a few articles published about the concept. But that was four years ago.

Since then I have set up my own analog and digital satellite station at home, became an AMSAT Area Coordinator, accepted the responsibility of the Southeast Michigan AMSAT net from Rich Ensign, N8IWJ, and even set up an Internet web page for the local AMSAT net. Hams in the area have asked to visit my satellite station or the station at Henry Ford Community College so they could see what this satellite stuff was all about. There have even been a few hams who have set up their own satellite stations as a result of these efforts. This is what it's all about, isn't it? Spread the word about what you can do on amateur satellites and hopefully recruit some new members for AMSAT-NA. This, after all is in all our best interest. More members means more financial support which results in more satellites for all of us to play on! I am always talking about satellite operations to folks on the local repeaters and sometimes I probably bore some people. The gears are always turning; how can I get more hams involved in amateur satellite operations? Hey, that section that I read about in the ARRL Handbook. The satellite gateway!

I've recently been involved with Dan Hancock, N8DJP, on his repeater projects.

I am an electronics technician working in the automotive industry and was interested in learning more about the RF end of electronics. Dan is very knowledgeable in this area and has been converting commercial radio gear to amateur use for years, including converting Motorola Micor commercial repeaters for local ham repeater use. I told Dan about the satellite gateway concept that I had read about four years previously and said I was interested in setting up such a system using my satellite station and his 2 meter repeater. He thought this was a great idea. So the quest began.

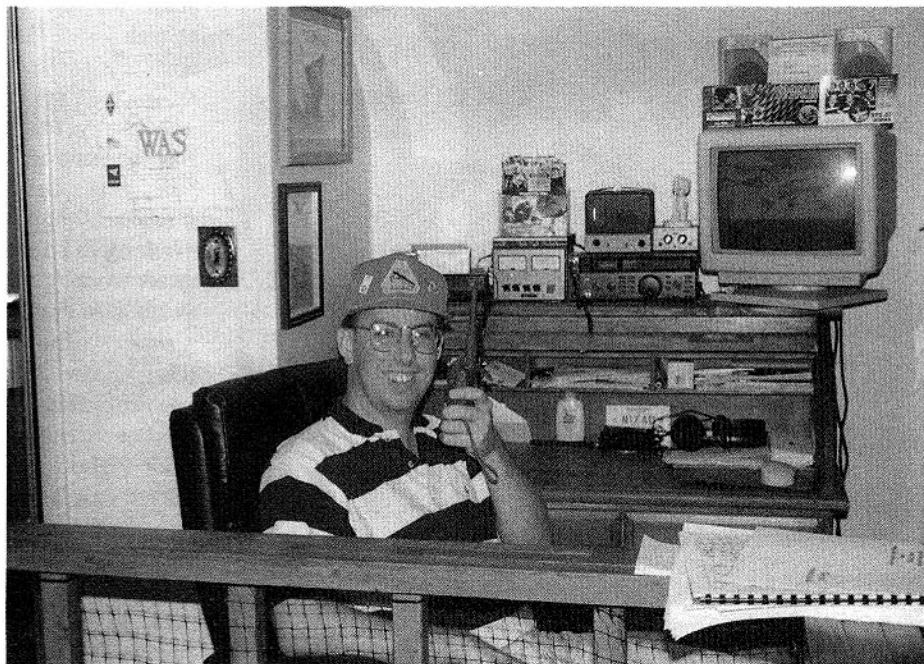
Control

The first thing I had to think about was how to control everything. WiSP, by Chris Jackson, G7UPN, and available from AMSAT, is a very versatile program, perfect for automation of a satellite station. WiSP is primarily used for digital satellite operations but it's also perfect for the automation of Doppler shift and antenna control. I wanted to be able to control the satellite gateway from a remote location and not have to worry about tracking the satellites manually. With WiSP, my station was already running automatically on the digital satellites. It uses a Kansas City Tracker/Tuner card to control my Yaesu

G5400 antenna rotor and Icom IC820H dual-band all-mode radio. I added the satellite I chose for the gateway, OSCAR 27, to the schedule.

WiSP will tune the satellite radio to the right frequencies, correct for Doppler, and at the same time control the az/el rotor while the satellite is in view. This was all I had to do to automate the satellite station. WiSP also has the ability to play a prerecorded sound (.WAV) file before the satellite comes up. The sound card is interfaced to the gateway and plays this prerecorded sound file over the repeater to announce that the satellite will be at the horizon in one minute.

The satellite station was now operational, but how could I interface this to the repeater? I needed something to control this process and a way to ID the station to meet Part 97 requirements. I pondered this idea for a while and found that Jim Millner, WB2REM, had already developed a great controller to handle this. His design was published in the January 1995 issue of *QST* and I thought about using his device. However, this would have involved either making my own PC board or wire wrapping the circuit. I had not made PC board layouts this complex and did not have the equipment to do it correctly.



The Author at his QTH in Dearborn, Michigan

the repeater. To solve this problem and eliminate repeater hang time from being transmitted up to the satellite, a PL decoder needed to be installed on my 2-meter receiver. Also, a PL encoder had to be installed on the repeater transmitter with the PL active only when a user is heard on the repeater input frequency. With this configuration, the only way other satellite users would know you are on a repeater uplinking to the satellite is if you told them or if the repeater happened to ID while the user was talking. The PL acts as a filter, keeping the repeater hang time, repeater voice IDs or messages from being heard over the satellite.

Satellite interface

Next I needed to interface the satellite radio to the controller. The remote base side of the controller was used for this process by connecting the remote base transmit audio to the IC820H, through the input on the microphone jack. The controller's remote base PTT logic signal also needed to be connected to the PTT input on the 820's microphone jack.

I had all the necessary hardware, now to hook it up. The first thing which needed to do be done was to set up the repeater link portion of the gateway. The gateway controller needed a source for receive audio and COS. (COS is a logic signal which tells the controller to key the transmitter when receive audio is present.) In my configuration I took the receive audio from the input side of the volume control and the COS logic signal from the PL board on the 2-meter receiver.

The transmitter also needed to be connected and, in this case, a 220 MHz HT, (a used Icom IC3AT I picked up for \$140), was interfaced to the controller. The controller supplied transmit audio out and

For the downlink receiver, the satellite radio's audio out (which is also available on the microphone jack on the Icom IC-820H) was connected to the controller's remote base receive audio input. The remote base COS logic was also needed and, on the 820, this logic signal is available on the data jack on the back of the radio. (The receive LED indicator lamp on a satellite radio could also be used to supply this logic signal.) Once this connection was made, I set audio levels on the radios and the controller, and programmed the controller. Refer to the block diagram for the controller-to-radio interface wiring in Figure 1.

Since I've had this gateway in operation (approximately 3 weeks at this writing), there has been a great amount of interest. It is nice to hear something different on the repeater than the usual traffic. Some of the hams in the area who I thought could have cared less about satellite operations have become very enthused about this gateway. Some have even talked about setting up their own satellite stations. And just think, I have not even linked to any DX birds yet!

[illegible]20 *The AMSAT Journal*

A Mobile Satellite Grid Square Chasing Vacation

Chuck Duey, KI0AG

It all started when the company I work for required that employees take a week of vacation. Yellowstone National Park came to mind, along with the idea of packing up some gear to operate satellites along the way. I talked with some friends who are grid-square chasers and soon a route was brewing. Soon after that, someone said "You'd make a lot of people happy if you hit North Dakota." So what started out going to Yellowstone, ended up a whirlwind tour of nine states. Soon the old wagon was loaded up with the gear, and I was headed out from my QTH in Denver, Colorado.

The first stop was Newcastle, Wyoming (DN73). After checking into the motel, I looked for a good spot to run FO-20. Just about two miles down the road was a historical marker with not too many trees or obstructions. First, the 2m Eggbeater went on the hood of the car for the uplink antenna. The downlink antennas consisted of a 70cm Eggbeater mounted on top of the car, and a LHP 12 element Yagi on a plastic cooler. FO-20 came up and at about 8 degrees above the horizon, it came in crystal clear. The lack of other RF noise made FO-20 sound like an FM repeater. About the last third of the pass I had to switch to a Yagi, which was pointed toward the direction of the satellite. At about 12 degrees above the horizon FO-20's signals started to fade.

Interestingly, after the FO-20 pass I looked up out of my car and noticed a large herd of deer. As I packed up the antennas and headed back to the hotel, there were several hundred deer close to the road and some of the deer wanted to play *dodge car*, so the trip back to the motel was slow. As I was driving back, I thought the downlink signals were so good, I would try a 30 degree pass an hour later. The trip back to that spot was just as slow, but the satellite pass went very well.

The next day I decided that I wanted to get to Yellowstone via North Dakota. After looking at the map, I headed toward Sundance, Wyoming and then on to Interstate 90. Once I got on Interstate 90, there was another pass of FO-20 coming up, so I looked for an exit. The road meandered down to a nice little fishing hole that was very quiet and scenic. Right by the fishing hole the antennas were set up and once

again the Eggbeaters and other antennas performed very well. At this point my setup and teardown was getting routine and was down to about four minutes.

Next on the agenda for the day was South Dakota and North Dakota. There was a major road construction zone just outside of Redig, South Dakota where cars were being guided through the site by a pilot vehicle. Since AO-27 AOS was only ten minutes off, and the pilot vehicle was not due for fifteen minutes, I pulled over and set up the HT and Dual band Yagi. I worked twelve hams from South Dakota right there in the construction zone. As I updated the log, the next pilot vehicle arrived; perfect timing!

North Dakota was uneventful. In Bowman North Dakota, I pulled off the road and waited for AO-27. I had my Yaesu FT-530 in one hand and an Arrow Dual band Yagi in the other. AO-27 was right on time and I made nine Hams very happy to work North Dakota. Afterwards, I got back in the car and drove west toward Montana.

Montana is a very big state! I needed to get from Bowman ND, to Yellowstone National Park in an afternoon. All the whip antennas held on the car quite well despite Montana's *safe and reasonable* highway speeds. That evening, as I rolled into Red Lodge, Montana it started to go down hill. A snow storm started as I drove towards Yellowstone and as I approached the Southern end of Red Lodge, there was a sign saying that the road was not yet opened for the season. One look at a map revealed there was a back road route

via Livingston. While on this backroad, I found a wide spot on the road to work FO-20. After working the satellite, I passed through a town and did not find a turn. I also noticed my GPS said I was way off course. Needless to say, I did not get in to Yellowstone that night as I checked into a hotel in Livingston.

The next morning was a bit cool, and Yellowstone National Park was only sixty miles to the south. On my way to Yellowstone, I came across a good parking spot by an entrance to a small community. I stopped there to work FO-20 in the cool morning air. After the pass as I was repacking my car, a local news reporter stopped to ask what I was doing with all the antennas. I explained carefully that I was talking on Amateur Radio satellites and she took a picture or two and left.

Finally I arrived at Yellowstone's north entrance and AOS for AO-27 was only twenty minutes away. I wanted to find a good spot for AO-27's first pass of the day. Unfortunately, there was an accident up the



KI0AG describing his portable AO-27 station at a show and tell session at the recent AMSAT Symposium in Tucson, AZ. (KC6JVB photo)

road, and Park Rangers were not letting any visitors through. As a result, I pulled off into a parking lot and brought out an antenna. I could only get about two minutes of AO-27's pass due to the mountains in the east. However, my plan was to be at Yellowstone for awhile, so one bad pass was not going to deter me. About one minute after AO-27's pass, a tow truck passed by with a mangled car, and the gates re-opened.

In the park there was still much snow piled up along the sides of the road. At one

point there was a large meadow of deep snow with the road nicely plowed and the buffalo herds decided that the road was a lot easier to walk on than the deep snow. Even though I was driving a large car, a mad buffalo could ruin my day so I carefully picked my way through the herd waiting for the openings to slowly creep by. After I was about half way through the herd, there were two small cars on my bumper following me. It took about ten minutes to get though and driving among such large animals is certainly an experience.

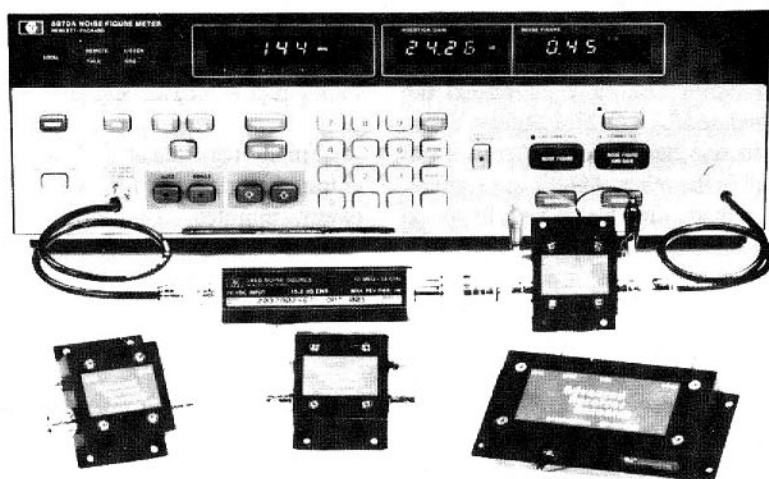
My first stop in Yellowstone was the Norris Geyser Basin. While there, RS-12/13 was very quiet, but I managed to contact a couple of Colorado stations from the parking lot. Afterwards, there was a good 30 minutes before any AO-27 passes, so I went down to view the geysers. AO-27 had its usual characters; busy as usual. I had some trouble with trees, but managed to make nine good contacts during the brief 10 minute pass.

My next stop in Yellowstone was Old Faithful where it started snowing. However, with the aid of a heavy coat, gloves and a hat I was ready out in the snow pointing the antenna in the parking lot. As I was working the satellite, someone drove by and asked me if I was tracking something. I replied, "Yes, an Amateur Radio Satellite." I think they were hoping that I would be able to tell them where to locate the buffalo.

With no more satellite passes until that evening, I watched Old Faithful go off twice during a nice windless snow storm. I took a couple of photographs, but with a white back ground and a white stream of steam and water, it all looked like a snow bank. After that I wandered into the Yellowstone lodge for a hot bite to eat. Then it came time to set up camp at Yellowstone. I had been given a site in the trees, not the best for working satellites, but I would try it out. The 2m Eggbeater went on the hood complete with a towel to keep from scratching the paint while the 70 cm Eggbeater was placed on the spare tire on the roof. A twelve element crossed Yagi was placed in a snow bank at a good angle for the next satellite. There were also 15m, 2m and 70cm whip antennas on my car so I cranked up the HF bands and chatted until the birds started to come up.

Every one I talked to on the satellites was very interested in Yellowstone and what the weather was like in early May. As I was talking, the campers across the road were setting up a tent. One of those heavy sleet storms started as they struggled to set up their tent. I was giving the play by play of these campers trying to set up a tent in the storm. The satellites did not seem to have much fade even in the heaviest of sleet so I continued to run satellites all night. I also worked some low FO-20 passes through the trees.

High Performance vhf/uhf preamps



Receive Only	Freq. Range (MHz)	N.F. (dB)	Gain (dB)	1 dB Comp. (dBm)	Device Type	Price
P28VD	28-30	< 1.1	15	0	DGFET	\$29.95
P50VD	50-54	< 1.3	15	0	DGFET	\$29.95
P50VDG	50-54	< 0.5	24	+12	GaAsFET	\$79.95
P144VD	144-148	< 1.5	15	0	DGFET	\$29.95
P144VDA	144-148	< 1.0	15	0	DGFET	\$37.95
P144VDG	144-148	< 0.5	24	+12	GaAsFET	\$79.95
P220VD	220-225	< 1.8	15	0	DGFET	\$29.95
P220VDA	220-225	< 1.2	15	0	DGFET	\$37.95
P220VDG	220-225	< 0.5	20	+12	GaAsFET	\$79.95
P432VD	420-450	< 1.8	15	-20	Bipolar	\$32.95
P432VDA	420-450	< 1.1	17	-20	Bipolar	\$49.95
P432VDG	420-450	< 0.5	16	+12	GaAsFET	\$79.95
Inline (rf switched)						
SP28VD	28-30	< 1.2	15	0	DGFET	\$59.95
SP50VD	50-54	< 1.4	15	0	DGFET	\$59.95
SP50VDG	50-54	< 0.55	24	+12	GaAsFET	\$109.95
SP144VD	144-148	< 1.6	15	0	DGFET	\$59.95
SP144VDA	144-148	< 1.1	15	0	DGFET	\$67.95
SP144VDG	144-148	< 0.55	24	+12	GaAsFET	\$109.95
SP220VD	220-225	< 1.9	15	0	DGFET	\$59.95
SP220VDA	220-225	< 1.3	15	0	DGFET	\$67.95
SP220VDG	220-225	< 0.55	20	+12	GaAsFET	\$109.95
SP432VD	420-450	< 1.9	15	-20	Bipolar	\$62.95
SP432VDA	420-450	< 1.2	17	-20	Bipolar	\$79.95
SP432VDG	420-450	< 0.55	16	+12	GaAsFET	\$109.95

Every preamplifier is precision aligned on ARR's Hewlett Packard HP8970A/HP346A state-of-the-art noise figure meter. RX only preamplifiers are for receive applications only. Inline preamplifiers are rf switched (for use with transceivers) and handle 25 watts transmitter power. Mount inline preamplifiers between transceiver and power amplifier for high power applications. Other amateur, commercial, and special preamplifiers available in the

1-1000 MHz range. Please include \$2 shipping in U.S. and Canada. Connecticut residents add 6% sales tax. C.O.D. orders add \$2. Air mail to foreign countries add 10%. Order your ARR RX only or inline preamplifier today and start hearing like never before!

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RS-15 was one satellite that was very problematic at my camp site. I heard its beacon, some QSO's, and started talking to a Ham in Ohio. However, every time he would say his callsign, all I could hear was horrible interference. The Ohio Ham did get my call and eventually I did get most of his callsign and name. Afterwards, I looked around and found there were two restrooms close by with a heater in each side that caused QRM when they were operating. Except, for these noisy heaters, Yellowstone was a very quiet place RF wise.

The next morning, snow and sleet froze all the antennas to my car and in the snow bank. What was worse, the towel under my 2-meter antenna was completely frozen to the hood. After warming up the car and packing other antennas, the towel melted enough to peel it off. After tossing a frozen towel in the back of my car, I went into West Yellowstone for some well-needed *hot coffee* and breakfast.

After breakfast, I was off to Idaho. Between US-20 and Interstate 15 there is a backroad that looked like a shortcut to the next square. I was not stopped from taking this road despite that it was a cold morning and there was a light dusting of snow. On down the road piles of snow emerged on either side of the road. Later, the road became snow packed, but with studded snow tires and chains for a back up I pressed on. Soon the road turned into an iceland with deep grooves. While the markers for the road were still clear, I felt like I was crossing a glacier at five mph. Soon, the ice suddenly ended, and there was dry road. Great! I was going to make it to Interstate 15 without backtracking.

Once on Interstate 15, I made a few QSOs in Idaho (DN34), Montana (DN35) and then headed to DN36 north of Butte, Montana. RS-12/13 went well and as usual not too many people are on it during the day. Later on, I was in a hurry to get on AO-27 and knocked the gamma match off of the Arrow dual band Yagi. I set that one against the car and pulled out the backup Cushcraft dual band. Once again I made many contacts on AO-27 and after the pass, I was hungry and wanted to get to a town for lunch. After putting the Cushcraft back in the car and beginning to drive off, I heard a strange metallic sound. The next time I set up the station, in Pocatello, Idaho, I noticed, the Dual band Arrow was missing. That

strange metallic sound was the antenna falling off my car as I drove away!

After spending the night in Pocatello, Idaho, I drove south to Salt Lake City, Utah. I was back into more populated areas, and set up for a pass at a rest area outside of town. There must have been one hundred people at the rest area looking at this old station wagon with antennas all over it. It seemed that every car passing by had ignition problems, and slowing down to look just made the noise longer lived.

After Salt Lake City, I made my way to Moab, Utah and Dove Creek, Colorado. It was pleasantly warm and dry in southwestern Colorado. I camped out with some friends, working satellites now and then. The next morning I decided to go to the Four Corners where Colorado, Utah, New Mexico and Arizona meet. On the way, I stopped on US-666 to work AO-27. After the pass, I noticed it was still quite a distance to the Four Corners. I was not watching my speed as I passed through a small town when the local deputy sheriff pulled me over for speeding. He looked at my car and noticed the back end was riding

low, and the spare tire was on the roof. Needless to say, he had to find out what sort of load I was carrying. In the back of the stationwagon, he found three large gel-cell lead acid batteries wired to a solar panel on the roof scattered among a spare tire and antennas. After running a license check he gave me a verbal warning about going through town fast and sent me on my way. I think the fact that I let him look at everything and had to pull out so many antennas was enough trouble for one speeder.

I made it to Four Corners with five minutes to spare even with that prolonged stop. While there were not too many people at the site, shops selling Indian trinkets were circled around the monument. AO-27 came up and since no one was

standing on the marker, I strolled out with my HT and dual band Yagi in hand. I made several contacts as KI0AG/5/7/7/0. A couple people walked up, I moved off the marker and continued talking. About 3 minutes before LOS no one was on the marker again, so I hopped back on and made a couple more contacts. As I finished I noticed everyone at the booths was looking at me and my Yagi.

I made a few more contacts around the Four Corners region and headed back to Denver. Even on the way back there were a few more chances to work AO-27 QRP standing beside the road with the Yagi in hand.

In total, it was a long seven day trek, through nine states, making contacts from nineteen grid squares. I made 124 contacts with 32 different hams during 39 passes. It was a lot of fun, and I would do it again, but I have to find a different set of squares to tackle. Occasionally I will still go on the road to get a few squares, so you never know where I'll pop up. 73 and catch you on the birds!! ■

Equipment Used on KI0AG DXpedition

Transceivers

- Yaesu FT-736R With RF Concepts 70cm and 2M Amp/Preamps (For FO-20, RS-12, RS-10 and RS-15)
- ICOM IC-706 (For RS-12, RS-10, RS-15 and HF work)
- Yaesu FT-530 - HT (For AO-27)
- Garmin GP-45 GPS for recording locations.

Antennas

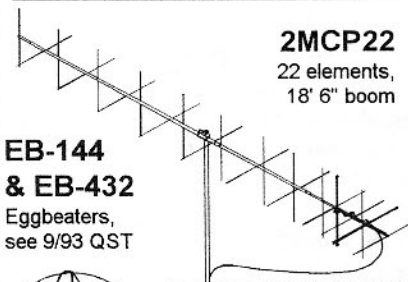
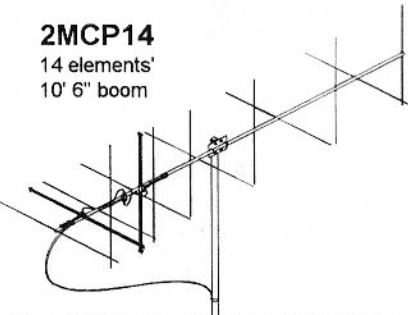
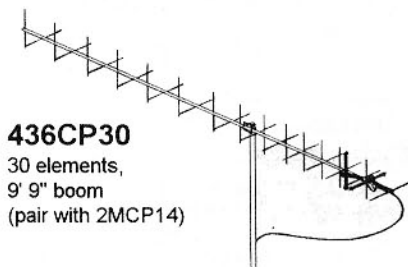
- M2 70cm Eggbeater (for FO-20)
- 12 Element crossed Yagi (LHP) (For FO-20)
- M2 2m Eggbeater (For FO-20, RS-12, 10 and 15)
- Arrow Dual band Yagi (For AO-27)
- Modified Cushcraft Dual band Yagi (For AO-27)
- 10m Hamstick (for RS-10 and RS-15)
- 15m Hamstick (for RS-12)
- 5/8 wave 2m (for low angle FO-20, RS-12 passes)
- MFJ dual band (General Purpose)
- 20m, 40m, 80m Hamsticks (for HF work)

Miscellaneous Equipment

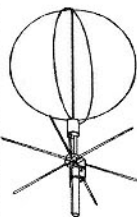
- 100 W solar panel (for charging Radio batteries)
- 3 65 AH 12 V gell-cells (For Radios)
- 486 SX 25 laptop for pass predictions
- Lots of warm clothes and sleeping gear
- One Large 1972 Ford Wagon with Studded Snow tires and two spare tires

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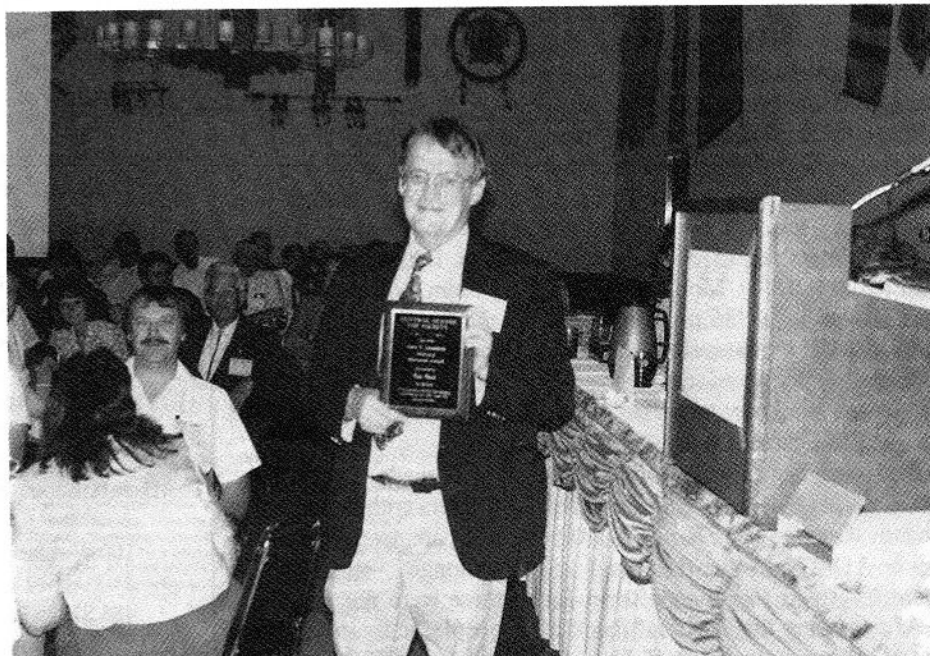
YES! You can have a piece of Phase 3D spacecraft hardware dedicated to you or, if you prefer, to your company or club. And, this beautiful 20x13 inch solid walnut plaque will forever attest to the major financial contribution made to the success of Phase 3D.



For each donation totaling \$2,500, a row of solar cells will be dedicated. Larger contributions will receive dedications of multiple rows of cells or some other piece of spacecraft hardware, such as computer memory, antennas, receivers or transmitters. All past contributions to Phase 3D will be credited toward the total contribution. Many have already qualified and will receive their plaques soon. The ARRL has already received its plaque dedicating to it, and its members, the Phase 3D spaceframe.

For further information, contact the **AMSAT** office at: 301-589-6062

Or write **AMSAT**, 850 Sligo Ave. Suite 600 Silver Spring, MD 20910



Tom Clark, W3IWI displays the plaque representing the *Chambers Award* he was presented at the 1996 Central States VHF Society Conference Banquet. The *Chambers Award* is presented by the Society to someone who has made an outstanding contribution to VHF and above. Tom's award was for his many years of amateur satellite work. (NW2L photo)

AMSAT Journal Telemetry

Vern "Rip" Riportella, WA2LQQ, SK

Vern Riportella, WA2LQQ, the third president of AMSAT-NA, died suddenly but peacefully on Friday, September 13, 1996 at his home in Warwick, New York. *Rip* was 53 years of age; the cause of death was a heart attack.

A former officer in the U.S. Air Force, "Rip" became active in AMSAT affairs in the late 1970s, rising to the position of executive vice president. He was elected president in 1984, serving until 1988. *Rip* tirelessly worked to create our present high-altitude transponder satellites. Without his unceasing devotion to fundraising, organizing, recruiting and the general encouragement of all concerned, AMSAT-OSCAR 10 (launched in 1983) and AMSAT-OSCAR 13 (launched in 1988) might never have become realities.

He also revitalized *The AMSAT Journal* and created a new publication, *AMSAT Satellite Report* (now *OSCAR Satellite Report*).

After his active days in AMSAT were over, *Rip* turned his attention to a new project, which was to become VITASAT. With the end of the Cold War, he did much to build bridges between Amateur Radio satellite enthusiasts in the West and their Russian colleagues. He also kept actively informed about AMSAT affairs, helping out wherever he could (e.g., in the installation and upgrading of packet radio equipment aboard Mir).

AMSAT-NA and the entire international Amateur Radio satellite community mourn Vern Riportella's loss. His enthusiastic spirit, needed now more than ever, will sorely be missed. I, myself, have lost a good friend. - Ray Soifer, W2RS. ■

AMSAT Election Results

AMSAT-NA Corporate Secretary Martha Saragovitz has announced the results of the annual election for the AMSAT Board of Directors. A total of 1645 members cast ballots in this year's election and the results are as follows:

Tom Clark.....	1303*
Keith Baker.....	1167*
Andy MacAllister.....	997*
Joe Holman.....	665#
Robert Diersing.....	561

* Elected to Board # Alternate Board Member

The three candidates receiving the highest number of votes were elected to serve on the Board for two years. The fourth highest vote-getter will serve as the



AMSAT-NA Vice President, Engineering Dick Jansson, WD4FAB (r) and AMSAT-DL member Konrad Mueller, DG7FDQ (l) perform a final inspection of Phase 3D's 400 Newton kick motor prior to its shipment to its shipment to Orlando for integration. (AMSAT-NA photo by KB1SF)



Bill Tynan, W3XO measures the gain of the Phase 3D prototype L-Band shot backfire antenna on a range set up by the Central States VHF Society Conference held last July in Minneapolis, MN.

alternate until the next election. The newly elected Board will meet at the site of the AMSAT-NA annual meeting in November. At that time they will elect AMSAT officers. ■

Phase 3-D Slated for Launch in April, 1997 on Ariane 502

In a published report released Thursday, September 26 by the European Space Agency (ESA), Mr. Jean-Marie Luton, Director General of ESA, and Mr. Alain Bensoussan, Chairman of CNES (the French Space Agency) announced that the launch of Ariane 502 has now been tentatively set for mid-April, 1997. It was also confirmed that the Phase 3-D International Amateur Radio Satellite will be on this flight. The other payloads are to be a pair of technological measurement packages for validation of the launch vehicle's ability to place two satellites into a geostationary transfer orbit (GTO).

These announcements came during a joint ESA-CNES press conference at ESA Headquarters in Paris called to outline the respective plans of the two agencies to correct identified deficiencies in the Ariane 5 launch vehicle. The actions are in direct response to a comprehensive report submitted in July by the Ariane 501 Inquiry Board that was chartered to investigate the loss on launch of the first Ariane 5 booster in early June.

During the press conference, it was also reported that ESA's Atmospheric Reentry Demonstrator (ARD), a technology demonstration capsule for a future European manned space transport vehicle, along with an as yet unspecified commercial payload, is to be flown on a subsequent Ariane 5 vehicle, Ariane 503, which has been made a part of the Ariane-5 qualification process.

This later flight could take place in September 1997. The ARD had earlier been

slated to fly on Ariane 502 along with the AMSAT Phase 3-D satellite.

In today's announcement, Mr. Luton and Mr. Bensoussan outlined several specific actions that are now being taken by ESA and CNES to assure the correction of software contained in the Ariane 5 inertial reference system. Errors in this software were previously reported by ESA as being one of the primary causes of the Ariane 501 failure. Corrective actions include making changes to the Ariane 5 Functional Simulation Facility to make the qualification tests more representative of the flight environment, as well as performing a comprehensive review of all the embedded software contained in the launch vehicle. ESA and CNES also announced that the industrial architect on the Ariane project will henceforth assume the role of *software architect*. This change will allow not only for verification of all software incorporated in equipment but also will help (continued on page 28)



SA AMSAT SATELLITE COMMUNICATION ACHIEVEMENT AWARD

This award is made in recognition
of having made twenty-five
two-way contacts through
Phase II Satellites.

..... AWARDS MANAGER

AWARD NUMBER

Have the AO-13 blues? Go out and get the **South Africa AMSAT Satellite Communication Achievement Award**! It is available to anyone making 25 contacts on any Phase II satellite (low earth orbit, i.e. AO-27, FO-20, FO-29, RS-10/11, RS-12/13, and RS-15). To obtain this award, send a photocopy of the front and back QSL cards to: Mike Scarcella, WA5TWT, 310 Lombardy, Sugar Land, TX 77478. Please include \$3.50 for AMSAT members and \$5.00 for non-members and two units of postage.

Current Amateur Satellite Frequencies

Analog Satellites

Satellite	Beacon (MHz)	Uplink (MHz)	Downlink (MHz) ¹	Type
AO-10 ²	145.810 and 145.987 ³	435.030-435.180 LSB/CW	145.975-145.825 USB/CW	Mode B
AO-27		145.850 FM	436.800 FM	Part-Time Repeater
FO-20 ⁴	435.795	145.900-146.000 SSB/CW	435.800-435.900 SSB/CW	Mode JA
FO-29	435.795	145.900-146.000 SSB/CW	435.800-435.900 SSB/CW	Mode JA
RS-10 ⁵	29.357	145.865-145.905 USB/CW	29.360-29.400	Mode A
RS-12 ⁶	29.408	21.210-21.250 USB/CW	29.410-29.450/145.910-145.950	Mode KT
RS-15	29.352	145.858-145.898 USB/CW	29.354, 29.394	Mode A

Digital Satellites

Satellite ⁷	Name or Callsign	Uplink (MHz)	Downlink (MHz) ¹	Type
UO-11			145.825 FM	1200 Baud PSK
AO-16	PACSAT	145.900, .920, .940, .960 FM	437.0513 SSB	1200 Baud PSK
DO-17	DOVE		145.825 FM	1200 Baud AFSK
WO-18 ⁸	WEBERSAT		437.104 SSB	1200 Baud PSK AX.25
LO-19	LUSAT	145.840, .860, .880, .900 FM	437.1528 SSB	1200 Baud PSK AX.25
UO-22	UOSAT5	145.900, .975 FM	435.120 FM	9600 Baud FSK
KO-23	HL01	145.850, .900 FM	435.175 FM	9600 Baud FSK
KO-25	HL02	145.870 FM	436.500 FM	9600 Baud FSK
IO-26	ITMSAT	145.875, .900, .925, .950 FM	435.822 SSB	1200 Baud PSK
POSAT	POSAT1	145.975 FM	435.2777 FM	9600 Baud FSK
FO-29	8J1JCS	145.850, .870, .890, .910 FM	435.910 FM	9600 Baud BPSK

MIR and SAREX

Spacecraft	Callsign	Uplink (MHz)	Downlink (MHz) ¹	Type
Mir	ROMIR	145.200 FM	145.800 FM	Voice or Packet
Mir	ROMIR ⁹	435.750 FM	437.950 FM	Repeater
Mir	ROMIR ⁹	435.725 FM	437.925 FM	Voice
Mir	ROMIR ⁹	435.775-436.775@25kHz spacing	437.975 FM	9600 Baud Packet
Shuttle	WSRRR	144.490 FM ¹⁰	145.550 FM	Packet
Shuttle	Various	144.910, .93, .95, .97, .99 FM ¹⁰	145.550 FM	Non-Mir Docking Missions
Shuttle	Various	144.450, .470 FM ¹⁰	145.840 FM	Mir Docking Missions

Notes:

- 1) Frequencies are shown without Doppler compensation. At start of typical LEO pass, the original signal will be several kHz higher than shown. Refer to specific satellite operating instructions for complete details.
- 2) For AO-10 and AO-13 Mode B, transmit in LSB, receive in USB. Also in Mode B, when the transmitted frequency is increased the received frequency will decrease (inverting transponder). AO-10 is no longer controllable but the transponder works when the satellite is in sunlight.
- 3) AO-10 beacon is an unmodulated carrier. Do not transmit to the satellite if the beacon is FMing.
- 4) Presently, FO-20 digital JD mode is not operational.
- 5) RS-10 Robot via 145.820 MHz uplink and 29.403 MHz downlink.
- 6) RS-12 Robot via 21.129 MHz uplink and 29.454 MHz downlink.
- 7) Digital satellites use a program suite containing PB/PG/PFHADD/PHS or WiSP.
- 8) WO-18 transmit experimental and image data and can be captured in KISS mode via PB or TLMDC.
- 9) Tentative frequencies for SAFEXII that are currently being tested. Refer to AMSAT News Services bulletins for additional information.
- 10) These are typical SAREX uplink frequencies. Refer to AMSAT News Service bulletins for exact SAREX frequencies.

(continued from page 26) insure the overall functional integrity of the launcher. Mr. Luton and Mr. Bensoussan went on to note that this means that all of the launch vehicle's software will now become subject to qualification reviews in which outside experts will take part.

In addition, the joint ESA and CNES announcement reported that working methods used in the Launcher Qualification Review have now been modified to introduce specialized audits on the most complex launcher systems in order to provide closer analysis wherever this is deemed necessary. A comprehensive review of the launcher's qualification is now also reported to be underway along with systematic efforts to identify degraded modes of operation that could affect launcher elements. ■

25th Annual SKN on OSCAR

You are most cordially invited to join in the 25th annual Straight Key Night on OSCAR, sponsored by AMSAT-NA for Amateur Radio satellite enthusiasts

worldwide. Activity has been growing each year.

It's entirely unofficial: no rules, no scoring and no need to send in a log. Just call CQ SKN in the CW passband segment of any OSCAR satellite, or answer a CQ SKN call from another station, from 0000 to 2359 UTC on January 1, 1997. OSCAR Zero (EME) contacts count too. Of course, all SKN operating must be done with a straight hand key.

Please nominate someone you work for recognition as having the *best fist*. To send in a nomination, address it via packet to W2RS @ WA2SNA.NJ.USA.NA, via the Internet to w2rs@amsat.org, or via snail-mail to W2RS' callbook address. Those nominated will be featured in a bulletin sent to Amateur Radio publications and posted to packet radio and the Internet in early February. ■

AMSAT at the Miami Tropical Hamboree

A five-hour workshop on how to use amateur satellites will be conducted at the

Miami Tropical Hamboree. The workshop will provide an introductory forum for amateurs interested in learning about AMSAT. Topics to be covered include:

- Equipment Choices (everything including pre-amps, power amps)
- Equipment Set-up
- Antennas, Rotators and Feedlines
- Software for Tracking
- Operating Protocol and Hints
- What Information is Available for You from AMSAT and ARRL
- Frequencies—What Countries or Regions You Can Work

What: Amateur Satellites — Today and Tomorrow - Be the Expert and start having Fun!

Who: Barry Baines, WD4ASW (AMSAT N.Fla Area Coordinator) and other area AMSAT experts will be your instructors.

When: Friday January 31, 1997, 2 PM - 7 PM. Arrive early to get materials.

Where: In association with the Miami Tropical Hamboree, Miami Airport Marriott - LeJeune Road

How: Space is limited; to pre-register write or call Rosalie White, WA1STO, at ARRL Headquarters (tel 860-594-0237, fax 860-594-0259) before January 13, 1997. Price is \$20 for ARRL members and \$25 for non-members. You will receive free materials and five hours of practical information. Sponsored by ARRL and AMSAT. You can also purchase *The Satellite Experimenter's Handbook*, from ARRL, beforehand, for \$20 + \$5 UPS shipping/handling.

Those who take part all day will also earn a certificate for 0.5 Continuing Education Units. ■

The ARRL Satellite Anthology 4th Edition Available

ARRL has recently announced the availability of *The ARRL Satellite Anthology, 4th Edition*. This edition contains 66 articles from *QST*, *The AMSAT Journal*, *WWW*, and other sources. Cost is \$12 and may be obtained via ARRL (pbusales@arrl.org). Please include \$4 for shipping and handling. ■

NEW SP-2000 & SP-7000 Heli-Filter SUPER-AMP PREAMPLIFIERS

Over eight years ago, we introduced our famous SP-2 and SP-70 SUPER-AMPS. We are now proud to introduce the SP-2000 and the SP-7000 --- a new generation of SSB Electronic 2 meter and 70cm mast mounted GaAsFET preamplifiers for Satellite, Weak Signal, Tropo, EME and ATVI

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	NF	GAIN	PTT	VOX
SP-2000	<0.8	10-20dB	750W	200W
SP-7000	<0.9	10-20dB	500W	100W
			PRICE	\$249.95

UEK-2000SAT Mode "S" Standard of Excellence High Performance Mast Mounted S-band Converters

- Super-low noise HEMT - RF amplifier with a NF of <0.6dB
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- Low Loss Flexible VHF - UHF - SHF Coaxial Cable
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82ft	\$71.34	164ft.	\$134.48
328ft.	\$252.56	"N"-conn	\$8.95

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Weekends 9:00AM - 11:00PM

OSCAR-13's Final Orbits

On perigee 6478/79, at around 1996 Nov 23 [Sat] 1140 UTC OSCAR-13's solar panel #3 ceased to function due to excessive heating.

On perigee 6479/80 at around 1996 Nov 23 [Sat] 2009:30 UTC panels #1,2,4,6 also stopped working, leaving only panel #5. The transponders were switched off by Graham VK5AGR shortly after his AOS at 1996 Nov 23 [Sat] 2314:15 UTC, orbit 6480 MA 99. Orbit 6480 continued on telemetry beacon only.

AO-13 survived perigee 6481, 1996 Nov 24 [Sun] 0432 UTC, perigee altitude 107km, monitored by insomniacs in Europe. The battery voltage was stable at 11.8 volts, much lower than the normal 14.5v. The on-board computer and related systems are regulated to 10.0v.

VK5AGR monitored the remainder of orbit 6481, but one solar panel proved insufficient to sustain a basic system, and the beacon stopped transmitting at 1996 Nov 24 [Sun] 0538:16 UTC, orbit 6481, MA 34. Reset commands, which would have left an unmodulated carrier, had no effect.

On orbit 6482 in Europe, 1996 Nov 24 [Sun] 1300 UTC onwards, neither of the beacons were detected, and the reset command was again ineffective.

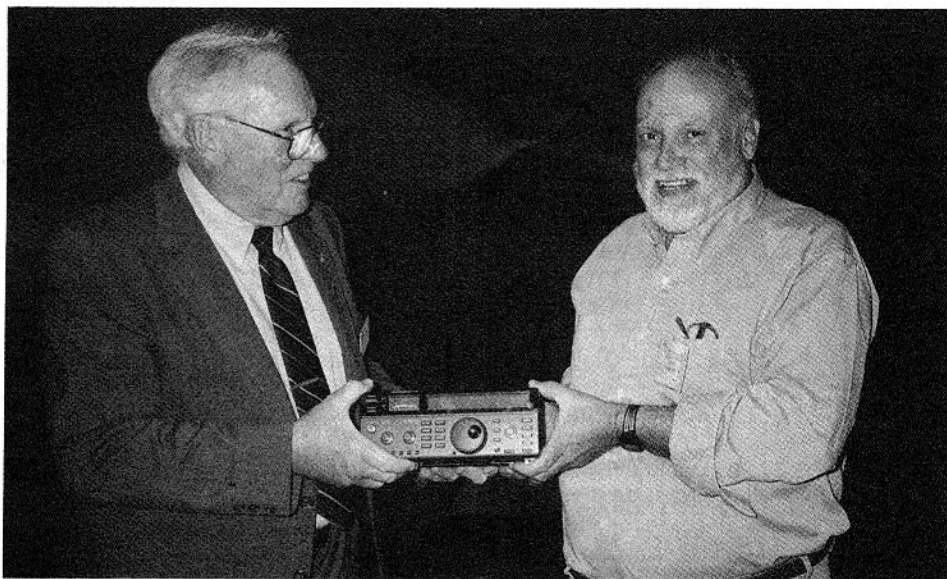
The command stations conclude that Oscar-13 is now defunct.

Re-entry is predicted for 1996 Dec 05/06 approximately, though experience with final orbits of decaying satellites indicates an enormous degree of uncertainty in these matters.

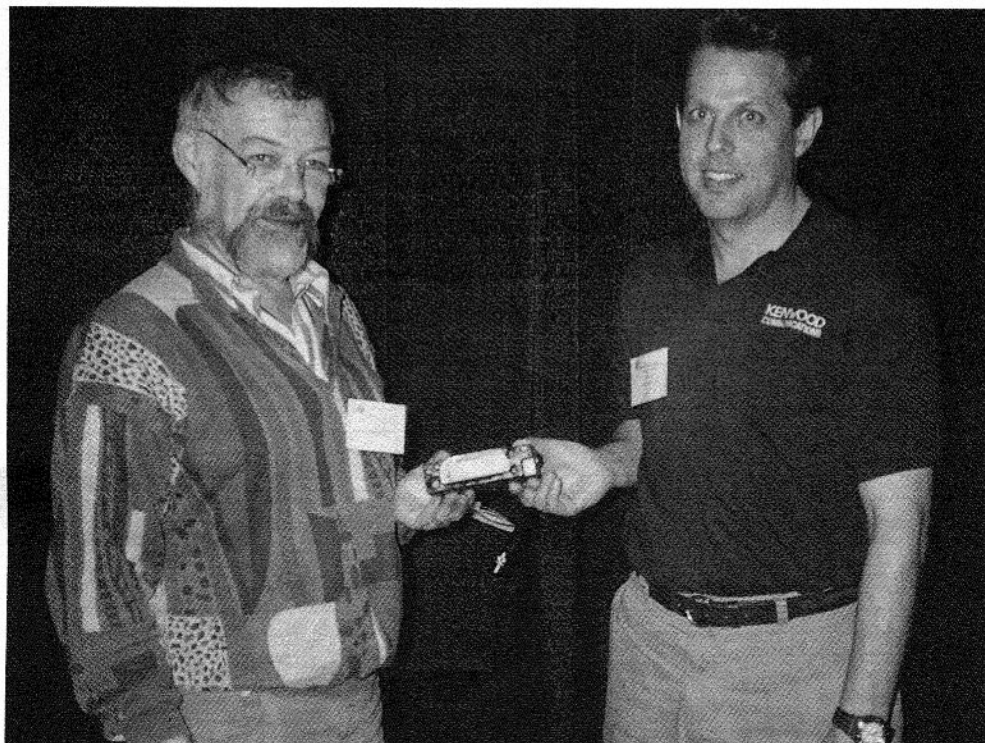
November's telemetry is archived at: <ftp://ftp.amsat.org/amsat/satinfo/ao13/telemetry/9611.zip> (956kb)

Much else connected with AO-13's re-entry is at <ftp://ftp.amsat.org/amsat/satinfo/ao13/decaykep.zip> (160kb) which includes temperature plots, Keplerian elements to re-entry, and other useful information.

The OSCAR-13 command stations are/were Peter DB2OS, Graham VK5AGR, Ian ZL1AOX, James G3RUH, and Stacey W4SM. They may be reached via Internet (callsign@amsat.org) and KO-23. Please remember to state a return address clearly. Notes



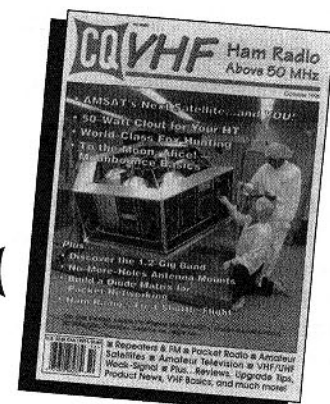
AMSAT-NA President Bill Tynan, W3XO, (L) presents an IC-820H, donated by ICOM America, to John Brand, K6WC, at the 1996 AMSAT Space Symposium banquet in Tucson, AZ (KB1SF photo)



Loren Pleet, AE6P, Sales Manager for Kenwood Communication's Amateur Radio Products Group, (R) presents their donation, a TM-251A, to Ib Christoffersen, OZ1MY, at the AMSAT Banquet. (KB1SF photo)

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Satellite Orbital Elements

Ray Hoad, W5QGD

Satellite	AO-10	AO-27	FO-20	FO-29	RS-10/11	RS-12/13	RS-15
Catalog Number	14129	22825	20480	24278	18129	21089	23439
Epoch Time	96285.03170314	96319.19322277	96319.08032374	96319.18593974	96319.16763785	96319.18994023	96318.99097
Element Set	458	528	933	53	300	939	185
Inclination	25.8858	98.5688	99.0233	98.5732	82.9257	82.9204	64.8132
RA of Node	184.997	31.9411	315.4175	23.42	37.6753	78.1	140.8275
Eccentricity	0.6048316	0.0008639	0.0541346	0.0352537	0.0013116	0.0028534	0.0156293
Arg of Perigee	56.3073	146.3168	144.7391	23.1592	95.5665	173.7132	172.3453
Mean Anomaly	347.4042	213.8567	219.0805	338.4996	264.6988	186.4383	187.9908
Mean Motion	2.0587993	14.27708632	12.83235163	13.52625839	13.72371241	13.74074626	11.27529189
Decay Rate	-0.0000015	-0.00000028	-0.00000019	-0.0000011	0.00000036	0.00000023	-0.00000039
Epoch Rev	10022	16339	31711	1205	47074	28963	7767
Satellite	EO-11	EO-14	AO-16	DO-17	WO-18	EO-19	EO-22
Catalog Number	14781	20437	20439	20440	20441	20442	21575
Epoch Time	96319.00468424	96319.14303773	96319.16521635	96319.17257386	96319.16564339	96319.14994684	96319.23803
Element Set	931	229	43	45	41	32	729
Inclination	97.812	98.5358	98.5505	98.5554	98.5545	98.5565	98.335
RA of Node	303.1681	39.2898	41.8019	42.5348	42.4502	42.9947	21.0298
Eccentricity	0.0011689	0.0011345	0.0011789	0.0011992	0.0012391	0.0012573	0.0007506
Arg of Perigee	336.5252	117.3489	120.1162	118.2589	119.0146	117.1152	171.1611
Mean Anomaly	23.542	242.885	240.1192	241.981	241.2282	243.1314	188.9709
Mean Motion	14.6949674	14.29937793	14.2998939	14.30131483	14.30100594	14.30211647	14.37043589
Decay Rate	0.00000095	0.00000004	-0.00000023	-0.00000017	0	-0.00000002	0.00000009
Epoch Rev	67965	35548	35550	35553	35553	35555	27961
Satellite	KO-23	KO-25	IO-26	POSAT	Mir	Hubble	Phase 313-502 (est)
Catalog Number	22077	22828	22826	22829	16609	20580	99934
Epoch Time	96319.15426098	96319.19374470	96319.17810784	96319.14227089	96319.15435535	96319.18626473	96260.25523447
Element Set	647	492	531	521	795	904	3
Inclination	66.0775	98.5648	98.5702	98.5673	51.6526	28.47	60.0203
RA of Node	235.4652	32.2068	32.1247	32.2281	86.1409	334.3083	342.7876
Eccentricity	0.0015241	0.001032	0.0009075	0.0010604	0.0013518	0.0005868	0.6752895
Arg of Perigee	261.4345	131.7527	147.6076	134.1595	29.5719	303.5326	180.1221
Mean Anomaly	98.4943	228.4539	212.5665	226.0464	330.6082	56.4699	179.5089
Mean Motion	12.86298354	14.28158383	14.27817889	14.28139984	15.62368486	14.91124998	1.51063968
Decay Rate	-0.00000037	0.00000012	0.00000011	0.00000009	0.00002007	0.00000373	0.00002
Epoch Rev	20009	13152	16340	16343	61350	16099	2

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